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CONTRACT NO. DE-AC05-86OR21548

WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1995

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JUNE 1996 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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APPROVALS

Department Manager — Date: 6/11/96

Quality Assurance Manager — Date: 6-18-96

Project Director (or Deputy Project Director) — Date: 6-18/96

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40 CFR Part 61 - Subpart H - *The National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities*

This *Weldon Spring Site Environmental Report for Calendar Year 1995* fulfills the requirement for an annual report as specified in 40 CFR 61.94. This statement applies only to the National Emission Standards for Hazardous Air Pollutants (NESHAPs) portion of the site environmental report (Section 6). This clause states:

"Each report shall be signed and dated by a corporate officer or public official in charge of the facility and contain the following declaration immediately above the signature line: 'I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001.'"

Jerry L. Van Fossen

for Stephen H. McCracken, Project Manager
Weldon Spring Site Remedial Action Project

DOE/OR/21548-592

Weldon Spring Site Remedial Action Project

EXECUTIVE SUMMARY

Environmental Report for Calendar Year 1995

Revision 0

June 1996

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 1995* has been prepared to provide information about the public safety and environmental protection programs conducted by the Weldon Spring Site Remedial Action Project (WSSRAP). The Weldon Spring site is located in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry. The chemical plant, raffinate pits, and quarry are located on Missouri State Route 94, southwest of U.S. Route 40/61.

The objectives of the *Site Environmental Report* are to present a summary of data from the environmental monitoring program, to characterize trends and environmental conditions at the site, and to confirm compliance with environmental and health protection standards and requirements. The report also presents the status of remedial activities and the results of monitoring these activities to assess their impacts on the public and environment.

This report includes monitoring data from routine radiological and nonradiological sampling activities. These data include estimates of dose to the public from the Weldon Spring site, estimates of effluent releases, and trends in groundwater contaminant levels. Additionally, applicable compliance requirements, quality assurance programs, and special studies conducted in 1995 to support environmental protection programs are discussed.

Dose estimates presented in this report are based on hypothetical exposure scenarios for public use of areas near the site. In addition, release estimates have been calculated on the basis of 1995 National Pollutant Discharge Elimination System (NPDES) and air monitoring data. Effluent discharges from the site under routine NPDES and National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring were below permitted levels.

MONITORING OVERVIEW

WSSRAP environmental management programs are designed to ensure that releases from the site are at levels demonstrably and consistently "as low as reasonably achievable" (ALARA). The ALARA principle drives the work activities related to site remediation and contaminant cleanup programs under U.S. Environmental Protection Agency (EPA) enforcement of the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA).

Effluent and environmental monitoring programs provide early detection of contaminants, assessment of potential impacts to the environment, and data needed to implement the ALARA strategy. Routine monitoring also demonstrates compliance with applicable State and Federal permits and regulations.

REGULATORY COMPLIANCE

The Weldon Spring site is listed on the National Priorities List (NPL) and is governed by the CERCLA. Under the CERCLA, the WSSRAP is subject to meeting or exceeding applicable or relevant and appropriate requirements of Federal, State, and local laws. Primary regulations include the *Resource Conservation and Recovery Act* (RCRA), *Clean Water Act* (CWA), *Clean Air Act* (CAA), *Toxic Substances Control Act* (TSCA), the *National Historic Preservation Act* (NHPA) and, because the U.S. Department of Energy (DOE) is the lead agency for the site, the incorporation of the *National Environmental Policy Act* (NEPA) values into CERCLA documents as outlined in the Secretarial Policy statement on NEPA.

Notable compliance activities included the final work plan and the sampling plan for the groundwater operable unit, which were submitted to DOE-HQ during 1995.

The Missouri Department of Natural Resources-Division of Geology and Land Survey (MDNR-DGLS) issued a Notice of Violation (NOV) to the Weldon Spring Site Remedial Action Project (WSSRAP) in November 1995 for temporary monitoring wells, which were left in the ground more than 30 days. Those wells have been removed and the issue resolved. The site submitted a proposed site treatment plan to the Missouri Department of Natural Resources (MDNR) in March 1995. One hundred and fifty-two polychlorinated biphenyl (PCB) capacitors were successfully decontaminated and shipped off site to Rollins Environmental in Deer Park, Texas on July 27, 1995. An NPDES permit violation occured when a quarterly sample, analyzed for biochemical oxygen demand (BOD) from the sanitary wastewater treatment plant, collected October 19, 1995, exceeded its permit limit. The cause of the violation was found to be cross contamination of the sample from contaminated sampling equipment.

MONITORING SUMMARY

Environmental monitoring data showed that dose estimates were below the U. S. Department of Energy guideline of 100 mrem (1 mSv) annual total effective dose equivalent for

all exposure pathways. NESHAPs air monitoring results for radioactive air particulates showed that dose estimates were all well below the NESHAPs standard of 10 mrem (0.1 mSv) per year. The 1995 radioactive airborne particulate release estimate was 4.3E-5 Ci (1.6E-6 Bq) and was assumed to be comprised (on an activity basis) chiefly of Th-230. This corresponds to a mass release of 0.014 kg.

Release estimates (which include storm water and water from the treatment plants) decreased from the 1994 release estimate of 0.071 Ci (2.6E-9 Bq) to 0.027 Ci (1.0E-9 Bq) in 1995. Effluent releases were below permitted limits. Data from groundwater and surface water monitoring indicated no measurable impact on drinking water sources from Weldon Spring site contaminants.

Dose Estimates

In 1995, the maximum total effective dose equivalent to a hypothetical individual who frequented the Weldon Spring Training Area was 0.041 mrem (0.00041 mSv). This scenario assumed an individual walking near the chemical plant perimeter 10 hours/year. The maximum total effective dose equivalent to a hypothetical individual at the boundary of the quarry was 0.12 mrem (0.0012 mSv). This scenario assumed an individual walking along the southeastern perimeter of the quarry 5 hours/year. The total effective dose equivalent to the maximally exposed individual at the vicinity property from consumption of fish tissue and inhalation of radioactive air particulates was 0.0079 mrem (7.9E-5 mSv). This scenario assumed an individual fishing at the slough and eating 6.5 grams of fish per day. This estimate is below the U.S. Department of Energy (DOE) guideline of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways. By comparison, the annual total effective dose equivalent in the United States due to naturally occurring sources of radioactivity is approximately 300 mrem (3 mSv).

The collective population dose equivalent for populations assumed to frequent the Busch Memorial Conservation Area was 0.043 person-rem (0.00043 person-Sv). The Busch Conservation Area estimate was based on an affected population of 160,000 persons assumed to have potential for exposure through ingestion of fish, water, and sediments.

Air Monitoring

During 1995, airborne releases from the Weldon Spring Chemical Plant (WSCP) area included radioactive particulates as measured by low volume gross alpha samplers and Rn-222 gas and progeny. Airborne releases from the Weldon Spring Quarry included both radioactive air particulates measured by low volume samplers and Rn-220 gas and progeny. Statistical analysis of air particulate data indicates that the concentrations at one WSCP perimeter monitoring location, and three quarry locations were greater than those recorded at the designated background location. Among the monitoring stations that exceeded background levels, none showed 1995 annual concentrations greater than the comparative 1994 annual concentrations.

The estimated off-site Rn-222 release was 15 Ci (5.6E-11 Bq) and the estimated off-site Rn-220 release was 3.3 Ci (1.2E-11 Bq). Statistical analysis of integrated radon data indicates that the concentrations at three stations at the raffinate pits and one station at the quarry were greater than background levels. Among the monitoring stations that were statistically greater than background measurements, none indicated 1995 annual concentrations greater than the comparative 1994 annual concentrations.

The results of NESHAPs monitoring for radioactive particulates indicated that all doses to the public at critical receptor locations were less than 1.0 mrem (0.01 mSv) per year. This dose is below the NESHAPs standard of 10 mrem (0.1 mSv) per year. Critical receptor locations upon which this dose was estimated included the Missouri Highway Maintenance Facility, Francis Howell High School, the WSSRAP administration building, the nearest quarry residence, and the Department of the Army Weldon Spring Training Area (Figures 5-1 through 5-3). Statistical analysis of NESHAPs monitoring results indicated that all stations were indistinguishable from background.

During periods of asbestos abatement work, airborne asbestos was monitored as a part of the nonradiological air monitoring program. Results indicated 303 of the 339 samples were above the detection limits. However, of those samples that measured above detection limits, low concentrations indicated that asbestos fibers were effectively contained during abatement operations.

NPDES Monitoring

In 1995, surface water runoff at the Weldon Spring Chemical Plant transported uranium from the site through six major discharge routes identified in Section 7 of this report. Radionuclide release estimates were calculated on the basis of the activity of uranium. The estimate of uranium released to water was 0.013 Ci (48.13E7 Bq) (19.1 kg) for U-234, 0.001 Ci (2.25E7 Bq) (0.9 kg) for U-235, and 0.013 Ci (47.65E7 Bq) (18.9 kg) for U-238.

Annual average uranium concentrations decreased at storm water Outfalls NP-0002, NP-0003 and NP-0005. Decreases at all three outfalls are attributed to precipitation patterns that had widely spread light rains and few heavy rains. The decrease at Outfall NP-0003 may also be partially attributable to management of Ash Pond and the installation of a sedimentation basin upstream of NP-0003. The average concentration decreased very slightly at the site water treatment plant and is attributable to normal plant operational variations.

The annual average concentration increased at storm water Outfall NP-0010. The increase is attributable to the clearing of the North Dump area for the construction material staging area (CMSA). The annual average also increased slightly at the quarry water treatment plant. This slight increase is attributable to normal plant operational variations.

The Missouri River was monitored during 1995 in support of site and quarry water treatment plant operations. Sediment samples were taken from the river both up and downstream of the treatment plant discharges and analyzed for uranium. The sample results indicate that the treatment plant discharges have caused no increase in uranium concentrations in river sediment.

Surface Water

Surface water monitoring in 1995 indicated that contaminant concentrations were within historic ranges.

Groundwater

The groundwater monitoring program included extensive monitoring for radiological and chemical compounds. Radiological results for the St. Charles County well field remained within

background levels. No detectable concentrations of the six nitroaromatic compounds of concern were found in groundwater monitoring wells south of the Femme Osage Slough, including the well field, which is near the quarry.

Environmental groundwater monitoring indicates that contamination is still present in the bedrock of the quarry rim and in the alluvial materials and bedrock north of the Femme Osage Slough. Some sample locations nearest the quarry show decreases in nitroaromatic compounds and radiological parameters. This is likely due to source (quarry bulk waste) removal.

The St. Charles County well field was inundated by the Missouri River from May to September; therefore, several monitoring wells were not sampled during the second quarter of 1995. No contaminant impact on the well field was detected in post-flood well field groundwater samples.

At the chemical plant, uranium, sulfate, nitrate, and nitroaromatic compounds in groundwater and springs remained near historic ranges. High concentrations of uranium typically occur in groundwater wells near Raffinate Pit 4 and at the southeast corner of the chemical plant. Contaminant transport continued to be primarily confined to the upper weathered zone of the bedrock aquifer at the plant; however, contaminant concentrations in at least one unweathered zone location south and west of the raffinate pits continued to increase during 1995.

Biological

The results of biological monitoring of fish from Busch Lake 36 showed uranium concentrations ranging from 0.002 pCi/g to 0.032 pCi/g (7.4×10^{-5} Bq/g to 0.0012 Bq/g) in edible portions. The calculated dose from ingestion of fish was found to be less than 1 mrem/yr (0.01 mSv/yr) and, therefore, does not pose a threat to human health.

Summarization of a 3-year aquatic study was completed during 1995 and average data are presented. It was concluded that aquatic invertebrate communities in areas that have been impacted by drainage from the site have not been adversely affected by contamination and that the dose to native aquatic organisms is below the protective guideline (<1 rad/day) as established in DOE Order 5400.5.

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ABSTRACT

This *Site Environmental Report for Calendar Year 1995* describes the environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). The objectives of these programs are to assess actual or potential exposure to contaminant effluents from the project area by providing public use scenarios and dose estimates, to demonstrate compliance with Federal and State permitted levels and regulations, and to summarize trends and/or changes in contaminant concentrations identified through environmental monitoring.

In 1995, the maximum effective dose equivalent to a hypothetical individual who frequented the Weldon Spring Training Area was 0.041 mrem (0.00041 mSv). The maximum effective dose equivalent to a hypothetical individual at the boundary of the Weldon Spring Quarry was 0.12 mrem (0.0012 mSv). The maximum effective dose equivalent to a hypothetical individual who frequents the Weldon Spring Vicinity Properties was 0.0079 mrem (0.000079 mSv). These estimates are below the U.S. Department of Energy requirement of 100 mrem (1 mSv) annual total effective dose equivalent for all exposure pathways.

The collective population dose equivalent for the population assumed to frequent the Busch Memorial Conservation Area (160,000 individuals) was 0.043 person-rem (0.00043 person-Sv). Results from radiological air monitoring for the National Emission Standards for Hazardous Air Pollutants (NESHAPs) program indicated that all estimated total effective dose equivalents were less than 1 mrem (0.01 mSv), which is below the U.S. Environmental Protection Agency (EPA) standard of 10 mrem per year.

Comprehensive monitoring indicated that emissions of radiological compounds in airborne and surface water discharges from the Weldon Spring site consisted primarily of radon gas and natural uranium and were estimated to be 18.3 Ci (6.8E11 Bq) and 0.027 Ci (1.0E9 Bq), respectively, for a total of 39,000 g (39 kg). There was no measurable impact to any drinking water source.

Various State and Federal permit levels are monitored under these National Pollutant Discharge Elimination System (NPDES) permits. Permit levels were maintained during 1995 except for four occasions when the administration building sewage treatment plant exceeded the permitted limits for biochemical oxygen demand (BOD) and total suspended solids (TSS) during February and one occasion in October when fecal coliform limits were exceeded.

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1 INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) is part of the U.S. Department of Energy (DOE) Environmental Restoration Program, one of the remedial action programs under the direction of the DOE Office of Environmental Management. This *Site Environmental Report for Calendar Year 1995* summarizes the environmental monitoring results obtained in 1995 and presents the status of Federal and State compliance activities.

DOE requirements for environmental monitoring and protection of the public, the mandate for this document, are designated in DOE Order 5400.1, *General Environmental Protection Program*, DOE Order 5400.5, *Radiation Protection*, and the implementation guide for DOE Order 5400.5: *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 1).

In 1995, environmental monitoring activities were conducted to support remedial action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), the *Clean Air Act* (CAA), the *National Environmental Policy Act* (NEPA), the *Clean Water Act* (CWA), and other applicable regulatory requirements. The monitoring program at the WSSRAP has been designed to protect the public and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Site Environmental Report for Calendar Year 1995* include:

- Providing general information on the WSSRAP and the current status of remedial activities.
- Presenting summary data and interpretations for the 1995 environmental monitoring program.
- Providing information regarding ongoing remedial actions.
- Reporting compliance with Federal, State, and local requirements and DOE standards.

- Providing dose estimates for radiological compounds as appropriate for the WSSRAP.

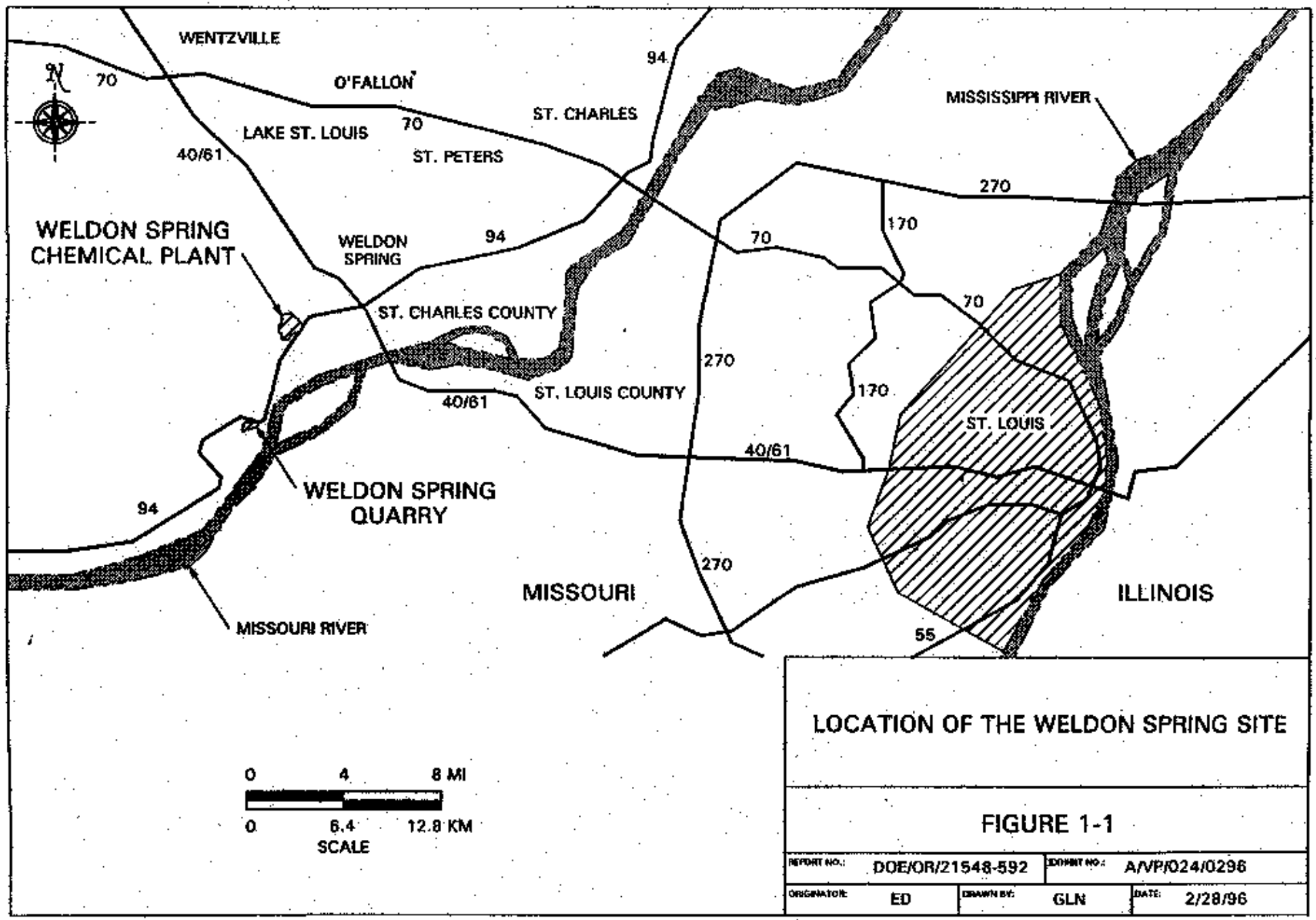
- Summarizing trends and/or changes in contaminant concentrations to support remedial actions, ensure public safety, and maintain surveillance monitoring requirements.

1.1 Site Description

The Weldon Spring site is located in southern St. Charles County, Missouri approximately 48 km (30 mi) west of St. Louis (Figure 1-1). The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94. Access to both the site and quarry is restricted by locked chain link fences with on-site security.

The Weldon Spring Chemical Plant is a 67.2 ha (166 acres) area which operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings were contaminated with asbestos, hazardous chemical substances, uranium, and thorium. (Building dismantlement was completed in 1994.) Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants can also be found in the soil in several areas around the site. The raffinate pits are located on the chemical plant site and include four settling basins that cover approximately 10.5 ha (26 acres) (Figure 1-2). These pits are radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, fluoride, PCBs, and various heavy metals.

The Weldon Spring Quarry is a former 3.6 ha (9 acres) limestone quarry located south-southwest of the chemical plant area (Figure 1-3). The quarry is essentially a closed basin; surface water within the rim flows to the quarry floor and into a sump. The amount of water in the sump varies in response to quarry water treatment plant operations and precipitation. The quarry bulk waste removal operation was completed in 1995. The bulk waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

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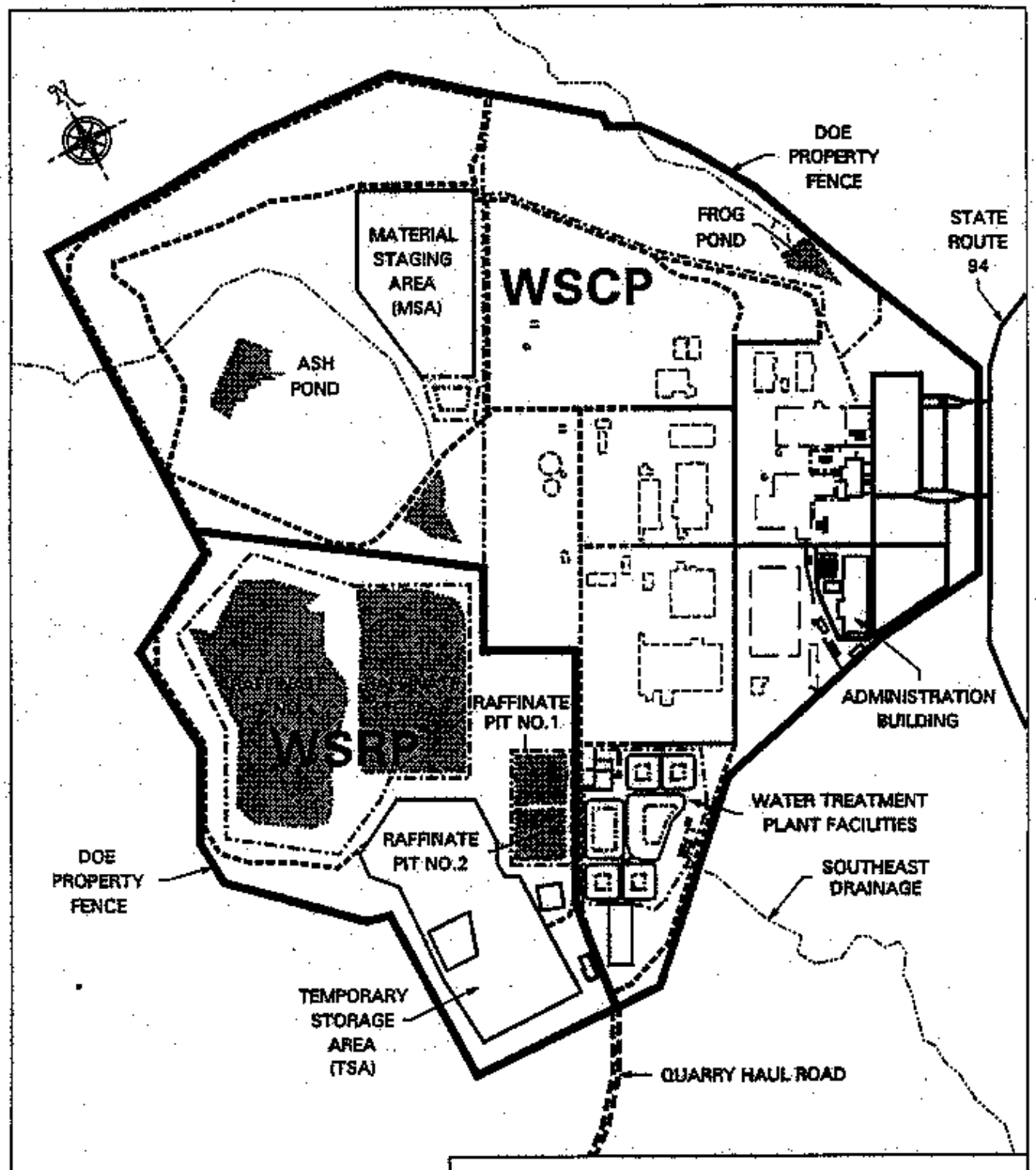

WELDON SPRING CHEMICAL PLANT AND RAFFINATE PIT AREAS

FIGURE 1-2

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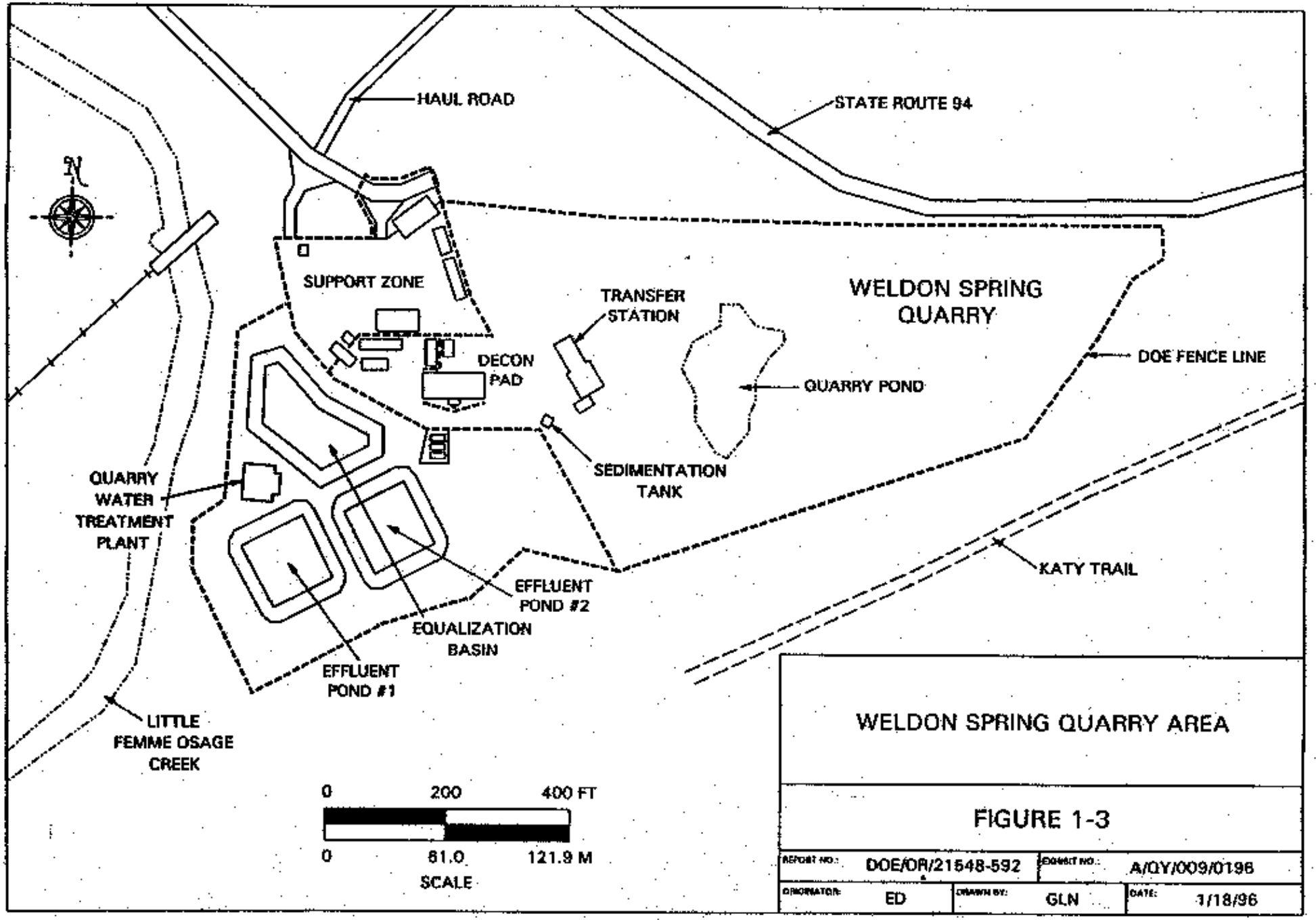

WELDON SPRING QUARRY AREA

FIGURE 1-3

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ORIGINATOR:	ED	DRAWN BY:	GLN
DATE:	1/18/96		

1.2 Site History

From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,233 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the State of Missouri (August A. Busch Memorial Conservation Area) and to the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Army training area.

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former ordnance works property was transferred in May 1955 to the AEC for construction of the WSUFMP, now referred to as the Weldon Spring Chemical Plant. Considerable explosives decontamination was performed by the Atlas Powder Company and the Army prior to WSUFMP construction. From 1958 until 1966, the WSUFMP converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium was also processed. Wastes generated during these operations were stored in the four raffinate pits.

In 1958, the AEC acquired title to the Weldon Spring Quarry from the Army. The Army had used it since 1942 for burning wastes from the manufacture of TNT and DNT and disposal of TNT-contaminated rubble during the operation of the ordnance works. Prior to 1942, the quarry was mined for limestone aggregate used in the construction of the ordnance works. The AEC used the quarry from 1963 to 1969 as a disposal area for uranium residues and a small amount of thorium residue. Material disposed of in the quarry during this time consisted of building rubble and soils from the demolition of a uranium ore processing facility in St. Louis. These materials were contaminated with uranium and radium. Other radioactive materials in the quarry include drummed wastes, uncontained wastes, and contaminated process equipment.

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. The Army started removing equipment and decontaminating several buildings in 1968. However, the defoliant project was canceled in 1969 before any process equipment was installed.

The Army retained responsibility for the land and facilities of the chemical plant, but the 20.6 ha (51 acre) tract encompassing the Weldon Spring raffinate pits was transferred back to the AEC.

The Weldon Spring site was placed in caretaker status from 1981 through 1985, when custody was transferred from the Army to the Department of Energy. In 1985, the DOE proposed designating control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major System Acquisition in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

A more detailed presentation of the production, ownership, and waste history of the Weldon Spring site is available in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 2) and the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 3).

1.3 Geology and Hydrogeology

The Weldon Spring site is situated near the boundary between the Central Lowland and the Ozark Plateau physiographic provinces. This boundary nearly coincides with the southern edge of Pleistocene glaciation that covered the northern half of Missouri over 10,000 years ago (Ref. 4).

The uppermost bedrock units underlying the Weldon Spring Chemical Plant are the Mississippian Burlington and Keokuk Limestone. Overlying the bedrock are unlithified units consisting of fill, top soil, loess, glacial till and limestone residuum of thicknesses ranging from a few feet to several tens of feet.

There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian Limestones and the middle aquifer consists of the Ordovician Kimmswick Limestone. The deep aquifer includes formations from the top of the Ordovician

St. Peter Sandstone to the base of the Cambrian Potosi Dolomite. Alluvial aquifers of Quaternery age are present near the Missouri and Mississippi Rivers.

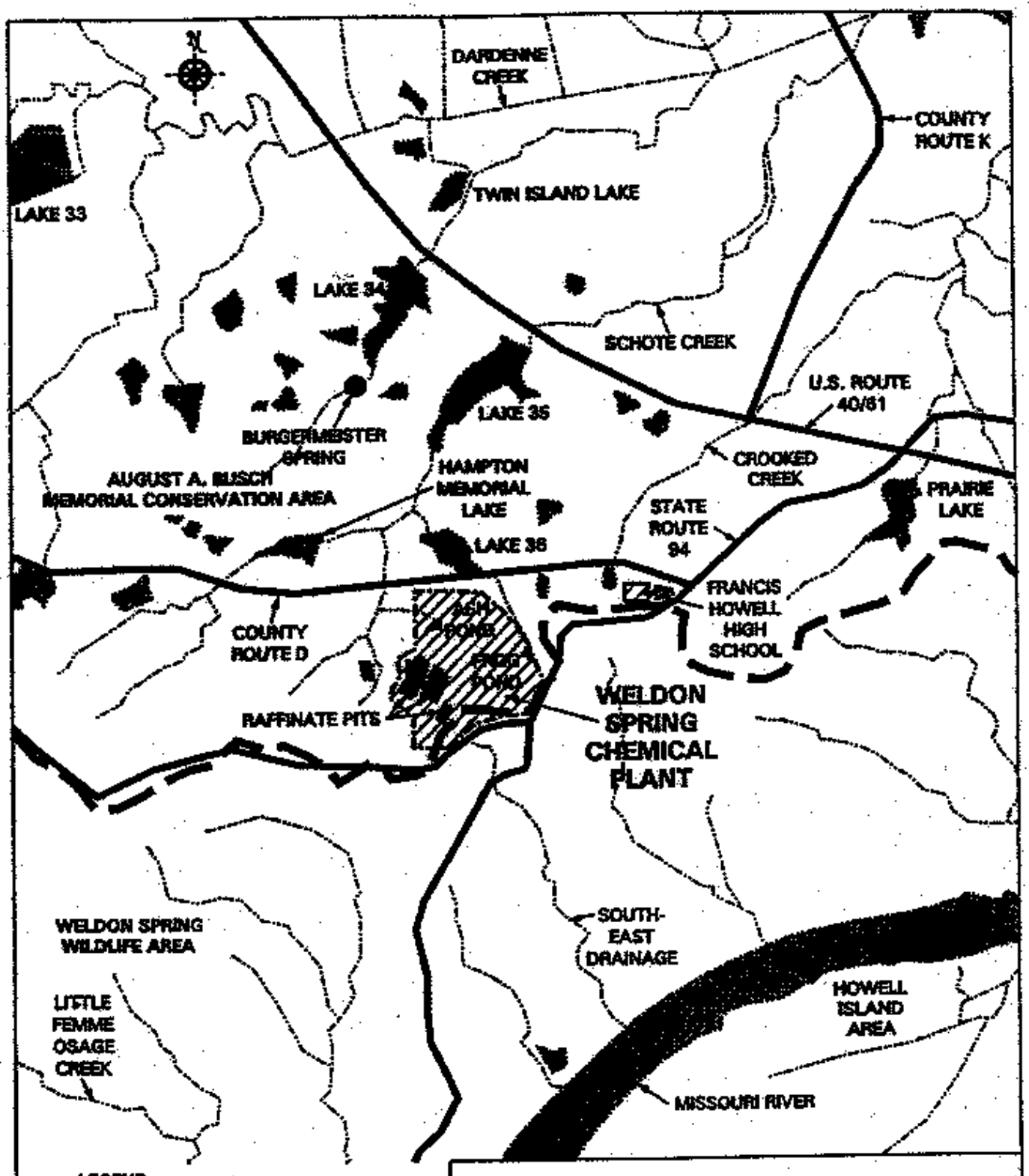
The Weldon Spring Quarry is located in low limestone hills near the western bank of the Missouri River. The mid-Ordovician bedrock of the quarry area is in descending order, the Kimmswick Limestone, Decorah Formation, and Plattin Limestone. These formations are predominantly limestone and dolomite. Near the quarry, the carbonate rocks dip to the northeast at a gradient of 11 m/km to 15 m/km (58 ft/mi to 79 ft/mi) (Ref. 4). Massive quatery deposits of Missouri River alluvium cover the bedrock to the south and east of the quarry.

1.4 Surface Water System and Use

The chemical plant and raffinate pits area is located on the Missouri-Mississippi River surface drainage divide (Figure 1-4). There were seven surface water bodies at the chemical plant area: four raffinate pits, Ash Pond, Frog Pond, and the MSA Pond. Ash Pond was drained and capped in late 1994 and the Frog Pond embankment was breached in 1995 and is nearly empty. Elevations on the site range from approximately 185.4 m (608 ft) above mean sea level (msl) near the northern edge of the site to 205 m (673 ft) above msl near the southern edge. The topography of the site is gently undulating in the upland areas, typical of the Central Lowlands physiographic province. South of the site, the topography changes to the narrow ridges and valleys and short, steep streams common to the Ozark Plateau physiographic province (Ref. 4).

No natural drainage channels traverse the site, although remnants of a channel through the Ash Pond area are present. Drainage from the southeastern portion of the site generally flows southward in a tributary referred to as the Southeast Drainage (5300 Drainageway), that flows to the Missouri River.

In the surrounding areas, man-made lakes in the August A. Busch Memorial Conservation Area are used for public fishing and boating. No swimming is allowed in the conservation area, although some may occur. No surface water is used for irrigation or as a public drinking water supply. The northern and western portions of the site, including Frog Pond and Ash Pond areas, drain to tributaries for Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River.



NATURAL RESOURCES IN THE WELDON SPRING SITE AREA

FIGURE 1-4

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During 1995, two sedimentation basins were constructed to minimize the discharge of sediment from the site as remediation efforts intensify. One basin is downstream of Ash Pond and collects Ash Pond runoff water as well as all waters that discharge at Outfall NP-0003. The second basin collects water from the northeast section of the site and discharges to Outfall NP-0002. These drainages, Burgermeister Spring, and Lakes 34, 35, and 36 are contaminated as a result of previous plant operations.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 km (1 mi) northwest of the Missouri River at approximately River Mile 49 (Figure 1-3). No direct surface water runoff enters or exits the quarry due to the topography of the area. A 0.07 ha (0.2 acre) pond within the quarry proper acts as a sump that accumulates both direct rainfall within the quarry and the groundwater. Past dewatering activities in the quarry suggested that the sump interacts directly with the local groundwater. Bulk waste removal, which included removal of some sediment from the sump area, was completed at the quarry during 1995. The surface area of the sump remains at 0.07 ha (0.2 acres). The quarry pond is not used for any operational or public water supply and is maintained by the DOE within an access controlled and restricted area.

The Femme Osage Slough, located approximately 213 m (700 ft) south of the quarry is a 2.4 km (1.5 mi) section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri dammed portions of the creeks between 1960 and 1963 during construction of a levee system around the University's experimental farms (Ref. 5). The slough receives contaminated groundwater migrating from the quarry, causing increased uranium concentrations in the slough. The slough is used for recreational fishing.

1.5 Ecology

The Weldon Spring site is surrounded primarily by State Conservation Areas that include the 2,828 ha (6,988 acres) Busch Conservation Area to the north, the 2,977 ha (7,356 acres) Weldon Spring Conservation Area to the east and south, and the Howell Island Conservation Area, an island in the Missouri River which covers 1,031 ha (2,548 acres) (Figure 1-4). The wildlife areas are managed for multiple uses, including timber, fish and wildlife habitat, and recreation. Fishing comprises a relatively large portion of the recreational use. Seventeen percent of the area is open fields that are leased to sharecroppers for agricultural production.

In these areas, a percentage of the crop is left for wildlife use. The main agricultural products are corn, soybeans, milo, winter wheat, and legumes (Ref. 6). The Busch and Weldon Spring Conservation Areas are open year-round, and the number of annual visits to both areas totals about 1,200,000 (Appendix A).

Much of the chemical plant area consists of maintained grasslands and old fields (65.5 ha [162 acres]) that are periodically mowed. Grasses and forbs are found in this habitat including big bluestem, timothy, red tip grass, foxtail, fescue, thistle, and goldenrod. The northwest portion of the chemical plant area (22 ha [54 acres]) is relatively natural and contains forest habitat typically found in the upland areas of eastern Missouri.

The quarry is surrounded by the Weldon Spring Conservation Area, which consists primarily of forest with some old field habitat. Prior to bulk waste removal, the quarry floor consisted of old-field habitat containing a variety of grasses, herbs, and scattered wooded areas. Since bulk waste removal began this habitat has been disturbed. The rim and upper portions of the quarry still consist primarily of slope and upland forest including cottonwood, sycamore, and oak (Ref. 5).

1.6 Climate

The climate in the Weldon Spring area is continental with warm to hot summers and moderately cold winters. Alternating warm/cold, wet/dry air masses converging and passing through the area cause frequent changes in the weather. Although winters are generally cold and summers hot, prolonged periods of very cold or very warm to hot weather are unusual. Occasional mild periods with temperatures above freezing occur almost every winter and cool weather interrupts periods of heat and humidity in the summer (Ref. 7).

Long-term meteorological records (since 1870) for the St. Louis area were examined to obtain information relevant to the Weldon Spring site. The average annual temperature is 12.8° C (55.1° F). The average daily maximum and minimum temperatures are 19° C (66.2° F) and 6.5° C (43.8° F), respectively. Maximum temperatures above 32.2° C (90° F) occur 35-40 days per year. Minimum daily temperatures below 0° C (32° F) occur about 111 days of the year. Temperatures below -18° C (0° F) are infrequent, occurring only 2-3 days per year. Mean annual precipitation in the area is approximately 94.0 cm (37.0 in.).

Wind data recorded at St. Louis for the period 1941 to 1970 indicate that prevailing winds are from the south during summer and fall, and from the northwest and west-northwest during winter and early spring. The average annual wind speed is about 4.3 m/s (9.5 mph) from the south.

The meteorological station located at the chemical plant provides data to support site environmental monitoring programs. The station provides data on wind speed, wind direction, ambient air temperature, relative humidity, solar radiation, barometric pressure, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which help determine possible impacts of airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

On-site meteorological data recovery exceeded 99% in 1995. The quality of all data was assured by a qualified off-site meteorologist. Averages and totals are presented in Table 1-1. An annual wind rose is presented as Figure 1-5.

1.7 Land Use and Demography

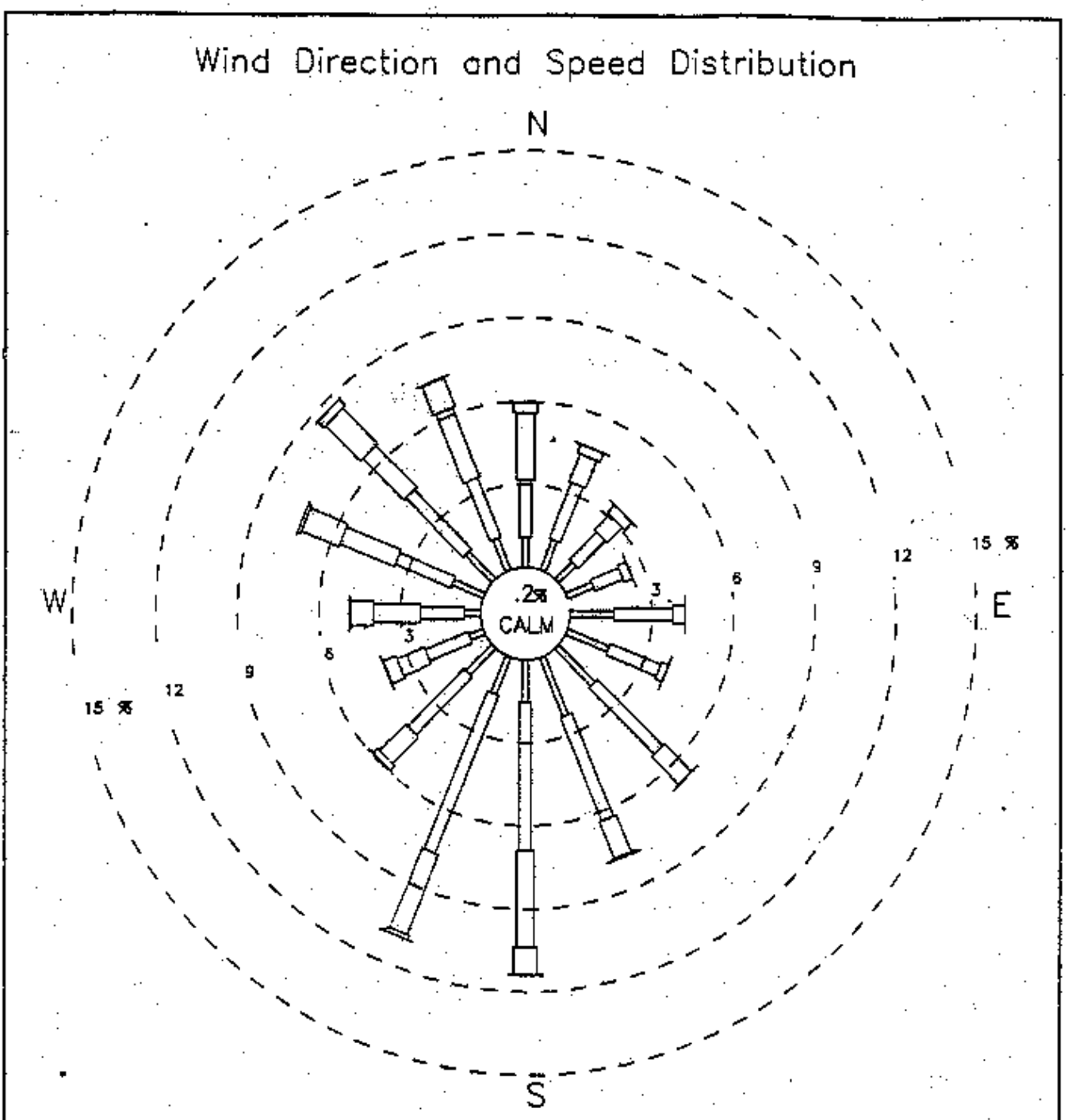
The population of St. Charles County in 1990 was 212,907; 20% of the population lives in the city of St. Charles, approximately 22.4 km (14 mi) northeast of the Weldon Spring site. The population in St. Charles increased by 48% from 1980 to 1990. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 mi) to the northeast. The combined population of these two communities in 1990 was 1,131 (see Appendix A). No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses.

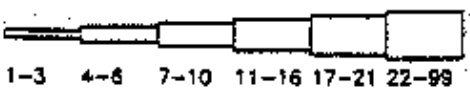
Francis Howell High School and the Missouri Highway and Transportation Department are both within 1 km (0.6 mi) of the site (Figure 1-4). Francis Howell High School is about

TABLE 1-1 Monthly Meteorological Monitoring Results for 1995

MONTH	TOTAL PRECIP (IN.)	AVERAGE TEMP (DEGREES C)	AVERAGE BAROMETRIC PRESSURE (MILLIBARS)	AVERAGE WIND SPEED (M/SEC)	PREDOMINANT WIND DIRECTION
January	1.27	-0.8	992	3.04	N
February	1.76	1.7	994	3.36	NW
March	3.84	8.8	994	3.26	WNW
April	3.54	12.8	988	3.35	SSW
May	10.14	16.8	989	2.59	SE
June	1.97	22.6	990	2.06	SSW
July	3.06	25.6	990	2.28	SSW
August	6.00	26.7	991	1.79	SSW
September	1.34	18.1	994	2.28	S
October	2.80	14.8	990	3.31	SSW
November	0.88	5.2	993	3.71	S
December	2.66	0.6	996	2.99	NW
Annual Average/ Total	39.26	12.7	992	2.83	SSW (11.7%)

1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs approximately 200 faculty and staff, and about 2,427 students attend school there (Appendix A). Students and staff generally spend about 7 hours to 8 hours per day at the school. The buildings are also used for other activities, such as athletic events and school meetings. The Missouri Highway and Transportation Department, located adjacent to the north side of the chemical plant, employs nine full-time employees (Appendix A). About 300 ha (741 acres) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land is being developed into a high-technology research park. The conservation areas, operated by the Missouri Department of Conservation, employ 16 full-time employees supplemented by 10 to 20 workers during the summer months (Appendix A).





1–3 (21 %) 4–6 (44 %) 7–10 (26 %) 11–16 (8 %) 17–21 (1 %) 22–99 (0 %)

WIND SPEED SCALE (MPH)

NOTE – WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

1995 ANNUAL WIND ROSE FOR THE WELDON SPRING SITE

FIGURE 1-5

REPORT NO.: DOE/OR/21548-592	EXHIBIT NO.: A/PI/004/0196	
ORIGINATOR: ED	DRAWN BY: SRS	DATE: 1/23/96

2 ENVIRONMENTAL PROTECTION/RESTORATION PROGRAM OVERVIEW

2.1 Project Purpose

The U.S. Department of Energy (DOE) is responsible for the remedial action activities at the Weldon Spring site. The program is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment posed by the waste materials on the Weldon Spring site and, to the extent possible, make surplus real property available for other uses.

Remedial actions are subject to U.S. Environmental Protection Agency (EPA) oversight under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) of 1980, as amended by the *Superfund Amendments and Reauthorization Act (SARA) of 1986*. Remedial actions at the site are subject to CERCLA requirements because the site is listed on the EPA National Environmental Priorities List (NPL). Section 3 of this document further discusses applicable Federal, State, and local compliance requirements and the current status of compliance activities at the Weldon Spring site and incorporating *National Environmental Policy Act* (NEPA) values into CERCLA documents as outlined in the secretarial policy statement on NEPA.

2.2 Project Management

In order to manage the WSSRAP under the CERCLA, the proposed strategy for remedial activities at the Weldon Spring site is organized into the following four separate operable units: Weldon Spring Quarry Bulk Waste, Weldon Spring Chemical Plant, Groundwater, and Quarry Residuals. The Weldon Spring Quarry Bulk Waste Operable Unit includes all wastes deposited in the quarry and their removal. The Weldon Spring Chemical Plant Operable Unit includes the buildings, soils, raffinate pits, quarry bulk wastes that have been relocated to the temporary storage area (TSA), and surface waters within the chemical plant boundary and vicinity properties. The Groundwater Operable Unit includes the groundwater at the chemical plant and vicinity areas. The Quarry Residuals Operable Unit includes the quarry proper (post bulk waste removal), surrounding areas, surface waters, and groundwaters.

2.3 Environmental Monitoring Program Overview

The overall goal of the WSSRAP is different from that of most operating and production facilities for which DOE Order 5400.1, *General Environmental Protection Program*, was developed. At the WSSRAP, environmental monitoring is conducted as required by DOE Order 5400.1 to measure and monitor effluents and to provide surveillance of effects on the environment and public health. In addition to these objectives, environmental monitoring activities support remedial activities under the CERCLA. This requires a careful integration of WSSRAP activities to implement all the environmental and public health requirements of the CERCLA, DOE orders, and other relevant Federal and State regulations.

The WSSRAP also complies with DOE Order 5400.1 requirements for preparation and maintenance of an *Environmental Protection Program Implementation Plan* (EPPIP) (Ref. 8) and an *Environmental Monitoring Plan* (EMP) (Ref. 42). The EPPIP details the programs in place at the WSSRAP to provide management direction, environmental protection goals and objectives, the remedial status of the project, and the overall framework of the environmental protection program at the WSSRAP. The EMP details the schedule and analyses for performing effluent monitoring and environmental surveillance activities.

The WSSRAP environmental protection program involves radiological and chemical environmental monitoring and is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of substances in environment media at the facility boundary, in contaminant migration pathways, and in pathways subject to compliance with applicable regulations (e.g., *National Emission Standards for Hazardous Air Pollutants* [NESHAPs]) or permit levels and requirements (e.g., *National Pollutant Discharge Elimination System* [NPDES]). Environmental surveillance consists of analyzing environmental conditions within or outside the facility boundary for the presence and concentrations of site contaminants. The purpose of this surveillance is to detect and/or track the migration of contaminants. Surveillance data are used to assess the presence and magnitude of radiological and chemical exposures and to assess the potential effects to the general public and the environment.

The WSSRAP environmental monitoring program involves sampling various media for radiological constituents, primarily U-234, U-238, Ra-226, Ra-228, Th-230, and Th-232. These

radionuclides are the primary radiological contaminants of concern at the Weldon Spring site. Radiological monitoring is conducted routinely at perimeter locations and at off-site locations near the chemical plant and quarry for air particulates, ambient gamma radiation, and radon. Radiological monitoring is also conducted on NPDES discharges, streams, lakes, ponds, groundwater and springs.

Chemical monitoring is primarily conducted at the chemical plant and quarry areas, but also includes monitoring at off-site locations to confirm that no releases have occurred. The nonradiological compounds included in the routine 1995 monitoring program are metals, inorganic ions (nitrate and sulfate), and nitroaromatic compounds. Other non-radiological parameters monitored as part of the environmental monitoring program include asbestos at site perimeter air monitoring locations and geochemical parameters such as calcium, manganese, and sodium at selected groundwater locations. The geochemical data are used in characterization and contaminant flow transport studies.

2.4 Project Accomplishments in 1995

Several activities were completed in 1995 under the overall plan for remediation of the site. All four operable units are currently active, and major accomplishments for all units are detailed below.

2.4.1 Weldon Spring Chemical Plant Operable Unit

A significant event for 1995 was the completion of the final building dismantlement work package. This was a major project milestone. Design work for foundations, underground sewers and utilities, and contaminated soil removal has been completed; however, due to funding limitations, removal operations are scheduled to begin in 1996.

2.4.1.1 Site Water Treatment Plant. Ongoing discharges of treated water into the Missouri River have consistently been below the effluent standards set forth in the conditions of the chemical plant's NPDES permit. During 1995, 124,905,000 liters (33 million gallons) of contaminated water were treated and discharged. Construction of the site water treatment plant Train 2 was completed in September 1995. Train 2 is designed to treat the nitrate contaminated water in the raffinate pits.

2.4.1.2 RCRA/TSCA Storage. The *Resource Conservation and Recovery Act* (RCRA) and *Toxic Substance Control Act* (TSCA) storage facility, Building 434, was upgraded in June 1995 to support waste storage and other operation needs. Other activities included repair of the roof on one of the flammable storage sheds, sampling of approximately 300 drums for initial characterization for shipment to the DOE facility in Oak Ridge, Tennessee, compacting approximately 400 drums of radiological trash/personal protective equipment (PPE), and returning numerous laboratory samples to the original containers to ensure these samples will not remain on site after the waste has been treated.

2.4.1.3 Disposal Cell. Activities included completion of the chemical stabilization/ solidification (CSS) test pads, clarifying a free liquid waiver from the EPA and the Missouri Department of Natural Resources (MDNR) for placement of the CSS grout into the disposal cell and developing an acceptance criteria for certain waste from the adjacent Weldon Spring Ordnance Works. This CERCLA site is being cleaned up by the Department of the Army. The Design Review Board is currently reviewing the 100% design for the disposal cell. A waste acceptance criteria document was finalized and transmitted to the Department of the Army. This document specifies waste criteria that must be met by the Army in order to dispose of Ordnance Work area wastes in the WSSRAP disposal cell.

2.4.1.4 CSS Pilot Facility. CSS pilot testing was completed in 1995. Tests relating to dredging, dewatering, and pumping of raffinate sludge; radon and other gas emissions; and CSS grout mixing and product performance were conducted. Also, test pads were constructed to test grout from the CSS pilot facility for pumpability, set time versus strength, radon and thoron flux, and trafficability.

2.4.1.5 South Dump/Ash Pond Capping. This area received additional soil cover to isolate existing contaminated areas from surface water and to prepare the area for temporary storage of building foundations debris and contaminated soil.

2.4.1.6 Mixed Waste. The WSSRAP began treatment of mixed wastes under the Federal Facility Compliance Agreement (FFCA) site treatment plan in February 1995. The plan consists of eight treatability groups, (1) aqueous liquids, (2) inorganic sludges/particulates, (3) inorganic debris/metal/batteries, (4) contaminated debris, (5) liquid mercury, (6) reactives/oxidizers, (7) organic liquids, and (8) organic sludges. Full-scale treatment of each

waste stream follows bench testing of the waste stream, development of a detailed procedure outlining the treatment, and a briefing with the Missouri Department of Natural Resources representatives. The State is often briefed and a procedure implemented prior to bench testing.

The status of each group during 1995 is as follows:

Aqueous liquids: Treatment of this treatability group began in February 1995. Approximately 3,785 liters (1000 gal) were treated through batch treatment in a precipitation tank followed by further treatment through the site water treatment plant. Four drums of this group remain to be treated during early 1996.

Inorganic sludges/particulates: Bench testing of three waste groups was completed in 1995 and full-scale treatment will begin in 1996.

Inorganic debris/metal/batteries: Preliminary conceptual designs for treatment of this treatability group began in 1995.

Contaminated debris: Development of bench testing procedures began in 1995. Bench testing will be completed and full-scale treatment will begin in 1996.

Liquid mercury: Bench testing and full-scale treatment of this treatability group were completed in March 1995.

Reactives/Oxidizers: Bench testing of this entire treatability group, which consisted of several types of wastes, was completed in 1995. Full-scale treatment will begin in 1996.

Organic liquids/sludges: Composite sampling of approximately 300 drums was completed in October 1995 and analyzed at the laboratory operated by the Oak Ridge, Tennessee, DOE mixed waste incinerators. These drums will be prepared for shipment to the K-25 incinerator in 1996.

2.4.2 Weldon Spring Quarry Bulk Wastes Operable Unit

2.4.2.1 Quarry Water Treatment Plant. Due to slow recharge to the quarry pond, the quarry water treatment plant (QWTP) must be shut down periodically. During 1995, the QWTP treated and discharged approximately 41,635,000 liters (11 million gallons) of treated water. All discharges from this plant were within the effluent standards set forth in the conditions of the NPDES permit for the Weldon Spring Quarry.

A Missouri Department of Natural Resources (MDNR) inspection was conducted at the quarry water treatment plant on August 23. A follow-up letter was received by the MDNR indicating that the plant was in full compliance.

2.4.2.2 Bulk Wastes Removal. On September 27, 1995, bulk waste removal from the quarry was substantially completed in accordance with the *Record of Decision (ROD) for Management of the Bulk Wastes at the Weldon Spring Quarry* (Ref. 57). Final washdown of the quarry continued after the removal of bulk waste and was completed in the month of December. To date, 88,312 m^3 (116,200 cu yd) of bulk waste have been removed from the quarry.

Activities at the TSA included off-loading waste and placement of engineered controlled waste piles. Final placement of waste materials was completed in December.

Two nitroaromatic soil piles that were excavated from the quarry and are currently stored at the TSA failed the toxicity characteristic leaching procedure (TCLP) level of 130 μg/l for 2,4-DNT and are considered *Resource Conservation Recovery Act* (RCRA) characteristic wastes with the waste code D030. One pile contains approximately 3,822 m^3 (5,000 cu yd). The second stockpile contains approximately 13,227 m^3 (17,300 cu yd).

The analyses of the two nitroaromatic soil stockpiles are based on June 1995 boring samples from the smaller stockpile and grab samples of soil as it was excavated in the quarry and placed on the larger stockpile (one grab sample per 382 m^3 [500 cu yd]). The two sets of analyses show the average 2,4-DNT TCLP result for the smaller and larger stockpiles are 1,144 μg/l and 1,191 μg/l, respectively.

A field demonstration began in late 1995 to establish a treatment method for these waste piles. The field test will continue during 1996.

2.4.3 Weldon Spring Quarry Residuals Operable Unit

Characterization sampling for quarry residuals continued in 1995. Two addenda to the *Quarry Residuals Sampling Plan* (Ref. 11) were issued to cover soil sampling and radiological scanning within the quarry proper, and water sampling of the resurgent quarry pond. With a few exceptions, soil sampling and scanning within the quarry proper has been completed. The quarry recharge study, which is assessing the quality and equilibrium water level of the quarry pond, began in late 1995 and will continue into 1996.

Flooding, access agreement delays, and conflicts with remediation activities in VP-9 have delayed some soil sampling activities, installation of some monitoring wells and piezometers, and the last phase of the in situ groundwater study. Monitoring well installation was completed at the end of 1995. The other activities will be completed in the second quarter of 1996.

All characterization sampling for the *Remedial Investigation* and *Baseline Risk Assessment* is scheduled to be completed by August 1996. The first draft of the RI will be issued on September 30, 1996.

2.4.4 Groundwater Operable Unit

The final work plan (Ref. 66) and sampling plan (Ref. 67) for the groundwater operable unit were submitted to DOE-HQ during 1995. The WSSRAP and the U.S. Department of the Army worked together to jointly address the groundwater issues for the Weldon Spring chemical plant and the Weldon Spring Ordnance Works in these joint documents. The remedial investigation was conducted in 1995 and included a joint sampling effort by the DOE and the U.S. Army Corps of Engineers of all wells in the chemical plant and ordnance works areas. As part of the remeidal investigation seven new monitoring wells were installed and sampled, three angle borings were drilled, 15 springs were sampled, and ecological monitoring was conducted.

2.5 Incident Reporting - Environmental Occurrences in 1995

In accordance with DOE Order 5400.1, Chapter II, 2.(b), field organizations are required to prepare annual summary reports on environmental occurrence activities and to report this information in the annual site environmental report.

In 1995, five off-normal occurrences and one unusual occurrence of an environmental nature were reported under DOE Order, *Occurrence Reporting and Processing of Operations Information*. Table 2-1 lists these environmental occurrences for 1995 and the following paragraphs provide short descriptions.

TABLE 2-1 Environmental Occurrences CY1995[c]

OCCURRENCE REPORT NUMBER	OCCURRENCE DATE	SUBJECT OF OCCURRENCE
1995-0002(a)	01/18/95	Notification of planned remedial action activities within the Weldon Spring Quarry boundaries.
1995-0007(a)	04/28/95	Approximately 75.7 liters (20 gal) of hydraulic fluid leaked from CAT 245 excavator during digging operation at the inner quarry.
1995-0012(b)	08/12/95	Transite pipe was broken during soil removal activities.
1995-0024(a)	11/08/95	Notice of Violation on abandonment of in situ wells.
1995-0025(a)	11/09/95	Notice of non-compliance of the wastewater treatment plant effluent limit.
1995-0026(a)	12/01/95	(60.61 liters) 55 gallon drum released partial contents inside Flammable Shed 3.

(a) Off-normal occurrence.
(b) Unusual occurrence.
(c) See Section 3.2.2.1 for details.

Occurrence 1995-0002 involved WSSRAP requesting various State and Federal Agencies to review and provide comments on the applicability of the CERCLA Section 103 reporting requirements for planned remedial action activities currently underway at the Weldon Spring

Quarry. CERCLA contains provisions requiring notification to the government authorities whenever a reportable quantity (RQ) of a hazardous substance is released. The Project's position had been that planned remedial actions conducted in accordance with an approved *Record of Decision* are not reportable. However, based on recent guidance provided by DOE headquarters and Oak Ridge Operations General Council in collaboration with EPA Headquarters General Council, the Project has determined that planned activities entailing placement of bulk waste within the Weldon Spring Quarry boundaries should be reported; therefore, the National Response Center (NRC) was notified by telephone in accordance with the provisions of 40 CFR 302.8, *Continuous Releases*. Section 103(f)(2) of CERCLA provides relief from the immediate reporting requirements of CERCLA Section 103(a) for release of hazardous substances that are continuous and stable in quantity and rate. A follow-up written notification was submitted within 30 days, as required by 40 CFR 302.8.

Per discussions with EPA Region VII representatives, the Project Management Contractor (PMC) received guidance on the definition of "immediate" release reporting. The EPA emphasized that release reporting should not be delayed in order to determine hazardous chemical concentrations in the release. The PMC will minimize the time spent quantifying chemical concentrations in any future releases.

Occurrence 1995-0007 involved a leak from a CAT 245 excavator in the inner quarry. Approximately 75.7 liters (20 gal) of hydraulic fluid leaked from the excavator. The fluid was soaked up with absorbent booms and placed in a container.

Occurrence 1995-0012(b) is discussed in Section 3.2.2.1.

Occurrence 1995-0024 involved a subcontractor to the PMC constructing monitoring wells in accordance with Missouri State requirements as "temporary wells" per 10 CSR 23-4.010(8). These wells were not removed within the specified 30-day time frame as required by the regulation, nor was a variance requested to extend the temporary status of the wells as provided in 10 CSR 23.140, which resulted in a violation. In addition, these wells should have been reconstructed or retrofitted and certified as monitoring wells according to 10 CSR 23-4.60. The Missouri Department of Natural Resources-Division of Geology and Land Survey (MDNR-DGLS) issued a Notice of Violation (NOV) to the Weldon Spring Remedial Action Project (WSSRAP) in November 1995 for monitoring wells. The NOV was addressed

by abandoning of the wells which were the subject of the violation and was completed on November 16, 1995. Representatives from Engineering and ES&H conducted an assessment of the entire groundwater monitoring program in December 1995.

Occurrence 1995-0025 involved a NPDES permit violation. A quarterly sample for the wastewater treatment plant was collected October 19, 1995. Verified results were received November 2, 1995; however, preliminary data were received October 25, 1995. Data revealed that fecal coliform was out of compliance with the daily maximum limit (15,000 colonies per 100 ml - maximum limit 1,000 colonies per 100 ml). The incident was attributed to the use of contaminated sampling device and therefore was not indicative of poor efficient quality.

NPDES permit MO-0107701 standard conditions required this noncompliance to be reported to the MDNR within 5 days of receiving the data. This was not done. However, the PMC did communicate with the MDNR regional office by telephone on November 8, 1995 regarding the noncompliance. The MDNR regional office was provided a written notification November 9, 1995.

Occurrence 1995-0026 involved the overpressurization of a 55-gallon drum, which resulted in the release of approximately 60.6 liters (16 gal) of material. The lid blew off the drum and material sprayed onto the interior walls, ceiling, floor, and another drum inside a storage shed for flammable materials. The contents of the drum consisted of diesel fuel (45%), grease (45%), and silver paint (10%). The release was contained inside the locked flammable shed. The incident resulted after the consolidation of the above materials to improve pumpability and occurred between approximately 1630 hours on November 30, 1995, and 0700 hours on December 1, 1995. There were no personnel in the immediate area of the shed when the incident occurred. There were no injuries, and no material was released to the environment. The incident occurred because a constituent of one waste was incompatible with another, and this caused pressure to buildup slowly.

Releases reported to other agencies (i.e., the EPA, National Response Center [NRC]) are not discussed in this section. Refer to Section 3.2.2.1, Release Reporting.

2.6 Special DOE Order Related Programs

In addition to the direct program requirements and documentation required under DOE Order 5400.1, the DOE order specifically requests that other programs be presented in the annual site environmental report, including the groundwater protection management program, the meteorological monitoring program, and the waste minimization and pollution prevention program. This section also addresses other programs, such as self assessments, under DOE Order 5482.1B, the radiological control program, and the surface water management program at the WSSRAP.

2.6.1 Groundwater Protection Management Plan

The WSSRAP has a formal groundwater protection and management program in place. The policies and practices are documented in the *Groundwater Protection Program Management Plan* (Ref. 13). The plan outlines how monitoring programs will be developed to assess the nature and extent of contaminants in the groundwater, to evaluate potential impacts on public health, and to gather data for remedial decisions. All policies pertaining to groundwater monitoring, including well installation, decontamination, construction, sampling methods, and abandonment methods, are detailed in this plan. The *Plan* also outlines the hydrogeological characterization program conducted as part of CERCLA activities. These include groundwater sampling, water level monitoring, slug tests, tracer tests, and geologic logging.

2.6.2 Meteorological Monitoring Program

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. The meteorological station provides data on wind speed, wind direction, ambient air temperature, relative humidity, barometric pressure, solar radiation, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics, which determine possible impacts of airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

Since the completion of a system upgrade in August 1994, meteorological data recovery has exceeded 99%. An off-site meteorologist provides monthly data reviews and semiannual maintenance and performance checks for the station.

2.6.3 Surface Water Management Program

The WSSRAP maintains a surface water management program to ensure effective implementation of policies detailed in DOE Order 5400.5 and documented in the *Surface Water Management Plan* (Ref. 14). This program also incorporates the as low as reasonably achievable (ALARA) concept in the execution of the program.

This plan identifies existing and potential water sources, water quality categories, and provides the requirements and methodologies for proper control, management, and disposition of site waters. Erosion and water control, and water management for the quarry and site water treatment plants are also discussed. The key elements of the plan are source identification, characterization, monitoring, engineering controls, and management methods.

2.6.4 Radiation Protection Program

The U.S. Department of Energy issued 10 CFR 835 (*Occupational Radiation Protection)*, in December 1993 in the Federal Register; 10 CFR 835 sets the minimum acceptable occupational radiological control standards for DOE facilities. The regulation includes requirements for contamination control, ALARA practices, internal and external dosimetry, facility design and control, internal surveillances, instrumentation and calibration, worker training, posting and labeling, and release of materials from radiological areas.

As of December 31, 1995, the WSSRAP is in full compliance with all applicable sections of 10 CFR 835.

2.6.5 Waste Management Program

The waste management program involves characterization of hazardous chemicals and wastes found on site and proper storage of the waste. This program also encompasses the packaging and shipping of hazardous waste samples. Hazardous and mixed wastes are stored

in the on-site RCRA and TSCA storage facility, Building 434, at the asbestos storage area, and temporary storage area until a final treatment or disposal option is available. No RCRA waste was shipped off site in 1995; hence, the WSSRAP was not required to comply with RCRA manifest or biennial report requirements.

Waste minimization and pollution prevention activities at the Weldon Spring site have been combined and are described in the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 16). The key elements of this program are chemical control, training and awareness, work activity review, and a recycling program.

2.6.6 Training

Training is a key element of the environmental protection program. Through training, each employee is instructed in the policies and procedures related to environmental protection.

The training program can essentially be broken into three main areas: (1) required reading (2) special courses taught on site to convey specific policies or issues and, (3) off-site courses designed to provide instruction for specific areas. Department managers establish training matrixes for each employee to ensure a comprehensive understanding of position requirements and overall policies and program requirements.

3 COMPLIANCE SUMMARY

3.1 Compliance Status for 1995

The Weldon Spring site is listed on the National Priorities List (NPL), and therefore the Weldon Spring Site Remedial Action Project (WSSRAP) is governed by the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) process. Under the CERCLA, the WSSRAP is subject to meeting or exceeding the applicable or relevant and appropriate requirements of Federal, State, and local laws and statutes, such as the *Resource Conservation and Recovery Act* (RCRA), the *Clean Water Act* (CWA), the *Clean Air Act* (CAA), the *Toxic Substance Control Act* (TSCA), the *National Historic Preservation Act* (NHPA), the *Safe Drinking Water Act* (SDWA), *Endangered Species Act*, and Missouri State regulations. Because the U.S. Department of Energy (DOE) is the lead agency for the site, the *National Environmental Policy Act* (NEPA) values must be incorporated. The requirements of DOE Orders must also be met. Section 3.1.1 is a summary of WSSRAP compliance with applicable Federal and State regulations, and Section 3.1.2 is a summary of the WSSRAP compliance with major DOE Orders.

3.1.1 Regulatory Compliance Status

Comprehensive Environmental Response, Compensation and Liability Act

The WSSRAP has integrated the procedural and documentation requirements of the CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and the NEPA, as required by the policy stated in DOE Order 5400.4. For example, *Engineering Evaluation/Cost Analyses* (EE/CAs) and *Remedial Investigation/Feasibility Study* (RI/FS) documents including (RI/FS) work plans, which are CERCLA documents, contain the required NEPA information for *Environmental Assessments* (EAs) and *Environmental Impact Statements* (EISs).

The WSSRAP used NEPA and CERCLA supporting documentation to prepare the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 24). The ROD was signed in September 1993 by the Environmental Protection Agency and the Department of Energy. This decision document presents the selected remedial action

for the chemical plant area of the Weldon Spring site. The preferred remedy for the chemical plant area of the Weldon Spring site is removal, chemical stabilization/solidification of selected site wastes, and disposal on site. The ROD identifies monitoring requirements for this remedial action and for development of a *Mitigation Action Plan*. The final *Work Plan for the Remedial Investigation Feasibility Study for the Groundwater Operable Units at the Chemical Plant Area and at the Ordnance Works Area*, Weldon Spring, Missouri was submitted in August 1995 to the EPA, MNR, U.S. Army Corps of Engineers and the DOE. The sampling plan was attached as a appendix to the work plan. Both plans have been approved by the EPA and the DOE.

National Environmental Policy Act

On June 13, 1994, a memorandum from Hazel R. O'Leary, Secretary of Energy, was sent to all DOE secretarial officers and the department managers. The subject of the memorandum was the NEPA Policy Statement, which has been included in Appendix A. Specifically, the DOE will rely on the CERCLA documentation process for review of actions to be taken under CERCLA and will address NEPA values and public involvement procedures within the CERCLA documents.

Missouri Department of Natural Resources

The Missouri Department of Natural Resources-Division of Geology and Land Survey (MDNR-DGLS) issued a Notice of Violation (NOV) to the Weldon Spring Remedial Action Project (WSSRAP) in November 1995 for monitoring wells. The wells in the NOV did not meet the requirements of 10 CSR 23-4.010(8) for prompt abandonment of temporary monitoring wells.

The wells were not removed within the specified 30-day time frame required for temporary monitoring wells as required by 10 CSR 23-4.010(8); nor was a variance requested to extend the temporary status of the wells per 10 CSR 23-1.040. In addition, these wells should have been retrofitted to meet the construction requirements for monitoring wells as defined in 10 CSR 23-4.060 since the time limit for temporary monitoring wells was exceeded. The NOV was addressed by abandoning of the wells which were the subject of the violation was completed on November 16, 1995. Representatives from Engineering and ES&H conducted an assessment of the entire groundwater monitoring program in December 1995.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site are managed (as substantive applicable or relevant and appropriate requirements [ARARs]) as required by the RCRA. This includes characterization, consolidation, inventory, storage, treatment, and transportation of hazardous wastes that remained on site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and wastes that are generated during remedial activities.

A RCRA treatment, storage, and disposal permit is not required at the site since remediation is being performed in accordance with decisions reached under the CERCLA. Section 121(e) of the CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

The RCRA was amended by the Federal Facility Compliance Act (FFCA), which was enacted on October 6, 1992. The FFCA waived sovereign immunity for fines and penalties for RCRA violations at Federal facilities. However, a provision postponed that waiver for 3 years for mixed waste Land Disposal Restriction storage prohibition violations at DOE sites, and required the DOE to prepare plans for developing the required treatment capacity and treatment technologies for mixed wastes. Each plan was required to be approved by the State or the U.S. Environmental Protection Agency (EPA) after consultation with other affected States and consideration of public comment, and an order issued, by the regulator, requiring compliance with the plan. The Weldon Spring site submitted its *Proposed Site Treatment Plan* to the Missouri Department of Natural Resources (MDNR) in March 1995. Comments on the *Proposed Site Treatment Plan* were received from MDNR July 12, 1995, and were responded to August 15, 1995. The *Compliance Plan Volume* was revised in accordance with these comments. The *Agreement* was signed by the MDNR and the DOE by the required date of October 6, 1995.

Currently, two underground storage tanks that previously contained gasoline and diesel fuel remain on site and these tanks hold quantities of contaminated water. The tanks are scheduled to be removed during the building foundations remediation.

RCRA groundwater monitoring for regulated units is discussed in detail in Chapter 8.

Toxic Substances Control Act

Polychlorinated biphenyls (PCBs) that have been removed from service are stored on site. Regulation 40 CFR 761.65 requires that any PCB article or container be removed from storage and disposed of within 1 year from the date it was first placed in storage; however, the WSSRAP received a waiver of this requirement in accordance with the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 24). PCB wastes will be stored in an adequate PCB facility (meeting the requirements of 40 CFR 761.65[b]) until final disposition of the PCB wastes can be accomplished.

One hundred and fifty-two PCB capacitors were successfully decontaminated and shipped off site to Rollins Environmental in Deer Park, Texas on July 27, 1995. The capacitors were received by Rollins July 28 and were incinerated August 15. The Certificate of Disposal was received September 14. The boxes were returned to the site August 25.

Clean Air Act

CAA compliance requirements pertaining to the site are found in Title I -Nonattainments, Title III - Hazardous Air Pollutants (including National Emission Standards for Hazardous Air Pollutants [NESHAPs]) and Title VI - Stratospheric Ozone Protection. NESHAPs dose calculations for 1994 indicate the highest receptor activity was below the NESHAPs standard of 10 mrem (0.1 mSv).

St. Charles County is classified in the *Federal Register* of November 6, 1991, 56 FR 215 as a moderate nonattainment area for ozone. As a moderate ozone nonattainment area, the requirements would affect sources emitting nitrogen oxide (NO_x) and volatile organic compounds (VOCs). At present, these sources do not exist at the WSSRAP.

Under Title III, asbestos and radionuclides are hazardous air pollutants. The standards establish criteria for the control of radionuclide and asbestos emissions. WSSRAP monitoring programs for radionuclides and asbestos are described in detail in Sections 4 and 6, along with the 1995 status of the monitoring.

Currently, the potential major source categories existing at the WSSRAP do not exceed the threshold limits of 9.07 metric tons per year (mtpy) (10 tpy) of any single hazardous air pollutant or 22.7 mtpy (25 tpy) of a combination of hazardous air pollutants; nor does the project currently store over 3,780 liters (1,000 gal) of gasoline per container on site. Therefore, the project is not subject to the requirement for vapor recovery systems for gasoline distribution. However, the Project Management Contractor (PMC) will continue to monitor the various sources for applicability. The categories of radionuclide emitters are not yet listed because the criteria for defining major and area sources of these pollutants have not been selected. Upon promulgation of the Maximum Available Control Technology standards, the WSSRAP will develop appropriate plans to comply with the standard for each of these source categories.

Sections 608 and 609 of Title VI are applicable to the WSSRAP. Section 608 establishes requirements for national recycling and emission reduction of Class I and II substances (chlorofluorocarbons and hydrochlorofluorocarbons, respectively). The section makes it unlawful to release, vent, or dispose of any Class I or II substances. Requirements in Section 608 apply to servicing, repairing, maintaining, and disposing of any refrigeration system (old or new) or air conditioning system (old or new). Section 609 specifies requirements that pertain to servicing motor vehicle air conditioners and applies to all WSSRAP vehicles. The WSSRAP is complying with Sections 608 and 609 of Title VI of the 1990 CAA amendments by (1) implementing a phase-out policy of ozone-depleting substances by instituting controls in the purchasing and use of these substances; and (2) obtaining copies of the personnel training certifications and equipment approval records for personnel and subcontractors that service any WSSRAP ozone-containing equipment (e.g., refrigerators, heating, ventilating, and air conditioning [HVAC] units, abandoned refrigeration units) or any WSSRAP vehicle cooling system.

Clean Water Act

Effluents discharged to waters of the United States are regulated under the CWA through regulations promulgated and implemented by the State of Missouri. The Federal government has granted regulatory authority for implementation of CWA provisions to those states with a regulatory program that is at least as stringent as the Federal program.

Compliance with the CWA at the WSSRAP included meeting parameter limits set in four National Pollutant Discharge Elimination System (NPDES) permits (Permit MO-G679035 was terminated on November 27, 1995). Under these permits, both effluent and erosion-control monitoring are performed. Section 7 includes additional details on the NPDES permits.

During 1995, 41,635,000 liters (11 million gallons) of water was treated through the quarry water treatment plant (QWTP) and discharged through the QWTP NPDES outfall. In the same period, 124,905,000 liters (33 million gallons) of water was treated through the site water treatment plant (SWTP) and discharged through the SWTP NPDES outfall.

An NPDES permit violation occurred when a quarterly sample for the wastewater treatment plant was collected. See Section 2.5 for details.

Rivers and Harbors Act

The U.S. Army Corps of Engineers (CE) approved the borrow area activity under nationwide permit (NWP) Number 26 in March 1994 contingent upon the DOE and the Missouri Department of Conservation (MDC) executing a mitigation agreement. The agreement was signed by the MDC February 9, 1994, the DOE on November 21, 1994, and forwarded to the CE on November 21, 1994. On February 17, 1995, the CE approved the mitigation agreement and authorized the start of the project. At the request of the U.S. Department of Agriculture the agreement was modified on October 5, 1995, into a tri-party agreement allowing the Department of Agriculture to receive credit for creation of 2.83 ha (7 acres) of wetlands within the original project area. This action fulfilled the contingent requirements and allowed transfer of the funds necessary for the MDC to construct the replacement wetland area. See Section 3.4 on the *Mitigation Action Plan* for more details.

Vicinity Property (VP) B-9 an 8.9 ha ([22 acre] contaminated area adjacent to the Femme Osage Slough) was excluded from review during the remedial investigation phase of the Chemical Plant Operable Unit. In May 1995, Argonne National Laboratory (ANL) requested the St. Louis CE review the proposed project for *River and Harbors Act* impacts. On June 12, 1995, the CE determined that the remediation activity qualified for NWP 37, subject to the conditions of the permit. Remediation was completed in February 1996.

The notice of floodplain involvement and statement of findings for VP B-9 was published in the Federal Register (FR) Volume 60, Number 151, on August 7, 1995.

Federal Insecticide, Fungicide, and Rodenticide Act

The WSSRAP maintains compliance with *Federal Insecticide, Fungicide, and Rodenticide Act* requirements through inspection of controlled pesticide/herbicide storage areas. No application of restricted-use pesticides occurred during 1995.

Department of Transportation

Pursuant to HM-181, the WSSRAP conducted on-site training on the *Hazardous Material Transportation Act*. The training targeted personnel with responsibilities for hazardous materials transportation. The training covered classification of hazardous materials by new shipping names, new performance based packaging requirements, new requirements for marking, labeling and placarding, and proper segregation and modes of transportation. The appropriate personnel are current on the training requirements and retraining is required every other year.

Safe Drinking Water Act

Currently, the SDWA is not an applicable and/or relevant and appropriate requirements at the WSSRAP. The SDWA is currently being evaluated for its applicability to the groundwater and Quarry Residuals Operable Units.

Emergency Planning and Community Right-to-Know Act

The *1994 Emergency Planning and Community Right-to-Know Act (EPCRA) Tier II* report was completed and provided on March 1, 1995 to the local emergency planning committee (LEPC) and to the Missouri State Emergency Response Commission (MERC).

The Toxic Release Inventory (TRI) report was submitted on June 22, 1995, to the EPA for the two chemicals (hydrochloric acid and barium chloride) exceeding usage thresholds.

The WSSRAP continued to refine *Emergency Planning, Community Right-To-Know Act* (EPCRA) reporting requirements and developed a plan of action to assist in preparing EPCRA reports for chemical storage and use. A new software program was installed in January, and this system is capable of providing complete requirements under SARA Title III. The program also generates Tier II and TRI reports.

National Historic Preservation Act

The construction material staging area (CMSA) required expansion of the site fence line by 100 ft from the northeast to the northwest corner of the site. A Phase I archeological survey was conducted and no potentially eligible sites were found in the proposed expansion area. Hence, "No Effect" determination was made by the WSSRAP and the Missouri State Historic Preservation officer (MSHPO) concurred with the determination.

The area impacted by the proposed relocation of Missouri State Highway 94 in support of the borrow area development was included in the Phase I and Phase II surveys conducted in 1994 for the borrow area haul road. A "No Effect" determination was made for this area, and the MSHPO concurred with this determination.

In April 1995 a "No Effect" determination for VP B-9 was submitted to the MSHPO. The determination was based on previous correspondence from the MSHPO which stated "an archeological survey of contaminated areas is not warranted based on the potential health risks associated with conducting archeological investigations in radiologically contaminated areas." The MSHPO concurred with the "No Effect" determination.

Endangered Species Act

The U.S. Fish and Wildlife service provided a listing of potentially threatened and endangered species in the VP B-9 area. After consultation with ANL, the DOE-WS determined the project would not impact critical habitat.

Executive Order 11990 Protection of Wetlands

The notice of involvement for VP B-9 wetlands was published in the Federal Register (FR) Volume 60, Number 151, dated August 7, 1995. The 15-day public comment period was waived by the DOE in the notice. The area listed in the notice depicted a 0.64 ha (1.5 acre) impact. After full delineation of the area by ANL the true wetland impact was 0.10 ha (0.25 acre). The U.S. Army Corps of Engineers required no restoration or revegetation of the area. However, the area will be restored as stated in the Federal Register notice, except for revegetation, which will be completed to the requirements of the MDC (land owner).

The construction of the sedimentation/detention basins for the disposal cell impacted two small jurisdictional wetlands totaling less than 0.202 ha (one half of an acre). As the total wetland area impacted was less than the 2.47 ha (1 acre) minimum threshold for notification, the CE notification was not made and the activity was completed.

3.1.2 DOE Order Compliance

3.1.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment. DOE Order 5400.5 establishes nine primary standards and requirements for DOE operations to protect members of the public and the environment against undue risk from radiation. The DOE operates its facilities and conducts its activities so that radiation exposures to members of the public are maintained within established limits.

The annual dose to the maximally exposed member of the public as a result of activities at the Weldon Spring site was below the 100 mrem (1 mSv) guideline for all potential exposure modes. The 10 mrem (0.1 mSv) annual dose limit for public exposure to airborne emissions, excluding radon and its respective decay products as specified in 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*, was not exceeded in 1995. The appropriate dose evaluation techniques were used to assess 1995 environmental monitoring and surveillance data in compliance with this requirement.

The annual average uranium concentration at all NPDES storm water outfalls was below the derived concentration guideline (DCG) of an annual average of 600 pCi/l (22.2 Bq/l). Outfall NP-0001 was eliminated by removing the outfall pipe during May 1994 and monitoring

requirements were removed from the NPDES permit on August 4, 1995. There was no flow from NP-0001 during 1995.

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 1995 are being maintained in accordance with the requirement of this order. All reports and records generated at the WSSRAP in 1995, pursuant to DOE order requirements, presented data in the units specified by the applicable regulation or order.

3.1.2.2 DOE Order 5820.2A, Radioactive Waste Management. DOE Order 5820.2A establishes policies, guidelines, and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities. The Weldon Spring site was in compliance with the applicable portions of Chapter IV management of waste containing Area 11e(2) byproduct material and naturally occuring and accelerator produced radioactive material, Chapter V (decommissioning of radioactively contaminated facilities), and Chapter VI (administrative activities related to the *Waste Management Plan* [Ref. 20]). The types of wastes addressed in Chapters I, II, and III of the Order were not present at the site. While the term "low level waste" is used in the FFCA site treatment plan abatement order, we expect to be able to clarify the definition of these wastes to reflect that they are by product materials as defined in DOE Order 5820.2A.

3.1.2.3 DOE Order 5400.1, General Environmental Protection Program. The WSSRAP conducted both radiological and nonradiological environmental monitoring programs at the site and vicinity properties. Environmental monitoring required by DOE Order 5400.1 was conducted to measure and monitor effluents and to provide surveillance of their effects on the environment and public health.

The WSSRAP was in compliance with Order 5400.1 requirements for preparation of an *Environmental Protection Program Implementation Plan* (EPPIP) (Ref. 8). The EPPIP details programs in place at the WSSRAP to provide management direction, environmental protection goals and objectives, and the overall framework for the environmental protection program at the WSSRAP. The project has prepared an *Environmental Monitoring Plan* (Ref. 42) that is reviewed annually and revised as necessary.

In addition to the plans developed for overall environmental monitoring and protection, the WSSRAP annually reviews and revises, as necessary, the *Groundwater Protection Program Management Plan* (Ref. 13) and the *Waste Minimization and Pollution Prevention Awareness Plan* (Ref. 16). Refer to Section 2.6 for additional details.

3.2 Current Issues and Actions

3.2.1 Current Issues

3.2.1.1 National Emission Standards for Hazardous Air Pollutants Compliance. The WSSRAP has developed an alternate method for compliance with the requirements of 40 CFR 61 Subpart H. Point source and environmental monitoring has been mandated per 40 CFR 61.93 (b)(5), whereby air concentrations are monitored at six designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by the U.S. Environmental Protection Agency (EPA). The EPA has also approved the WSSRAP plan to report annual monitoring results and effective dose equivalents at critical receptor locations via the annual site environmental report.

3.2.2 Current Actions

3.2.2.1 Release Reporting. On January 17, 1995, at approximately 0720 hours, 3.6 kg (~8 lbs) of ethylene glycol was discovered leaking from a Grove 850 crane. The absorbent gravel and soils were placed in a container. The National Response Center (NRC) was notified of the exceedance of the RQ.

On January 26, 1995, at approximately 1400 hours, 0.91 kg (~2 lbs) of ethylene glycol was discovered leaking from a loose hose clamp on the radiator hose of a caterpillar excavator. The NRC was notified of the spill. The free liquid was absorbed and the soils and absorbent pads placed in a container.

On February 8, 1995, at approximately 1020 hours, 5.4 kg (~12 lbs) of ethylene glycol was discovered overflowing from a heavy equipment truck at the quarry buffer area. The NRC was notified. The spill was cleaned up and the absorbent pads were placed in a container.

On February 13, 1995, at approximately 0822 hours, .45 kg (~1 lb) of ethylene glycol was discovered overflowing from a Terex truck (heavy equipment truck) in the quarry buffer area. The NRC was notified. The free liquid was absorbed into the pads and placed into a container.

On Monday, February 27, 1995 at approximately 0310 hours, a pipe fitting failed during regeneration of the activated alumina at the site water treatment plant (SWTP) and approximately 567.7 liters (150 gal) of sodium hydroxide solution (pH-13) spilled. A small portion was diverted by a culvert into an on-site sedimentation basin containing approximately 1,135,500 liters (300,000 gal) of water. The spill was neutralized to a pH of about six. Personnel at the SWTP diverted the flow to the equalization basin and isolated the tank. The SWTP was temporarily shut down. Initially, this event was reported to the NRC; however, after additional information was gathered, it was determined that a reportable quantity (RQ) had not been released. A U.S. Environmental Protection Agency (EPA) Region VII follow-up report was prepared.

On July 6, 1995, at approximately 0829 hours, an employee vehicle radiator hose broke and released approximately 1.89 liters (.50 gal) of anti-freeze to the asphalt parking lot. Approximately 0.9 kg (2 lb) of ethylene glycol was released. The NRC was notified. The spill was cleaned up and the absorbent pads were placed in a container. The reportable quantity for ethylene glycol was .45 kg (1 lb).

The reportable quantity for ethylene glycol was adjusted from 2.2 kg to 11,000 kg (1 lb to 5,000 lbs) in the June 12, 1995, Federal Register. The effective date was July 12, 1995.

On Saturday, August 12, 1995, at approximately 0930 hours, a transite pipe was identified in the contaminated soil stock pile located north of Raffinate Pit 4 (Occurrence 1995-0012). The pipe was tracked over with the subcontractors front end loader and broken into several pieces. The pieces of pipe were loaded into haul trucks with soil and placed in the area of the chemical stabilization/solidification (CSS) test pads. It is estimated that approximately

2.3 kg (5 lbs) of asbestos was released. The reportable quantity for asbestos (friable) is .45 kg (1 lb). The release of the reportable quantity of asbestos was reported to the National Response Center and to the Missouri Emergency Response Center.

Occurrences noted under the DOE Order 232.1 are not discussed in this section. Refer to Section 2.5, Incident Reporting - Environmental Occurrences in 1995, for discussion of those occurrences. The WSSRAP did not have any EPCRA reportable releases.

3.2.2.2 Functional Appraisal - Environment, Safety and Health, and Quality Assurance. No functional appraisal was conducted at the WSSRAP during 1995.

3.2.2.3 Compliance with the Price-Anderson Act. The PMC has revised the *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 22), by applying the quality assurance criteria specified in paragraph (c) Quality Assurance Criteria, of 10 CFR 830.120. The PMC QAP includes a discussion of how the criteria in paragraph (c) will be satisfied.

On November 3, 1994, the PMC submitted to the U.S. Department of Energy a current PMC QAP and the *Project Management Contractor Quality Assurance Program Implementation Plan* (QAPIP) (Ref. 23).

The PMC QAP and *Implementation Plan* were approved by the DOE Assistant Secretary for Environmental Management on January 27, 1995. The PMC QAP has been revised to reflect changes to be incorporated for Calendar Year 1996.

The PMC submitted the *PMC Implementation Plan for Title 10 Code of Federal Regulations, Part 835 with Radiation Protection Program* to the DOE December 27, 1994. The program was reviewed by the DOE-ORO June 27, 1995. The WSSRAP has recently submitted requests for exemptions to certain requirements associated with radon, thoron, and associated progeny dose assessment.

3.3 Summary of Permits for 1995

Various permits were maintained by the WSSRAP for remedial activities including NPDES, excavation, and floodplain permits. Table 3-1 provides a summary of all NPDES and construction permits. Four active NPDES permits covered discharges from the site water treatment plant (MO-01077701), quarry water treatment plant (MO-0108987), storm water discharges from the borrow area and borrow area haul road (MO-R100B69), and hydrostatic test water discharges from site water treatment plant Train 2. No NPDES construction permits remain active.

3.4 Site Remedial Mitigation Action Plan

The progress of the mitigative actions for the remediation of the Weldon Spring site is reported annually via this document and in accordance with DOE Order 5440.1E. Information on the implementation of the *Mitigation Action Plan* (MAP) and the effectiveness of the mitigation action is included.

Construction activities at the Weldon Spring site are managed by using good engineering practices for control of surface water runoff at, and from, the site. Two sedimentation basins and three retention ponds have been constructed during 1995 at the chemical plant area in preparation for soil excavation activities planned for 1996. Straw bale placement and erosion control monitoring have been routinely conducted in 1995 for surface water and erosion control. Monitoring has been conducted at four outfall locations at the chemical plant and all requirements of the NPDES and *Missouri Clean Water Act* have been met.

The wetland mitigation agreement was signed in 1994 and construction of the replacement wetlands for the chemical plant area, borrow area, and haul road area are expected to begin in early 1996. Construction activities at the borrow area or the haul road did not eliminate wetlands in these areas during 1995. Erosion control measures were in place during construction to prevent sedimentation into the wetland areas. Clearing and grubbing activities were conducted in the Ash Pond area; this area, and the wetlands, were eliminated due to use of this area as a contaminated soil storage area. The levy of Frog Pond was breached in 1995 to allow the sediment to dry for additional characterization and removal. Pumping of surface water at the

TABLE 3-1 Summary of WSSRAP NPDES and Construction Permits

PERMIT NO.	(a)	DATE ISSUED	DATE EXPIRED	(b)	DATE RENEWAL OR EXTENSION REQUEST DUE	SCOPE AND COMMENTS
MO-0107701	O	03/03/94	03/04/99	Y	09/04/98	Covers storm water, sanitary, and SWTP discharges.*
MO-0108987	O	06/09/94	06/10/99	Y	01/10/99	Covers QWTP discharge.
MO-G879035	O	08/31/94	10/10/97	N	04/10/97	Covers hydrostatic testing at the SWTP Train 2. The permit was terminated on November 27, 1995.
MO-R100B69	O	09/01/94	06/11/97	N	12/11/96	Storm water discharges from the borrow area and haul road operations.
MO-R101389	O	12/07/92	12/12/96	N	Terminated 09/28/94	Covered land disturbance storm water discharges from the SWTP pipeline excavation.
22-4670	C	04/19/94	04/18/95	N	03/18/95	Covers nitrate removal system Train 1. Construction complete. Engineering Certification sent May 22, 1995 DIN. 52537.
22-4711	C	06/29/94	06/28/95	N	05/28/95	Covers SWTP Train 2 Basins. Construction complete. Engineering Certification sent June 12, 1995. DIN 53492.
22-4750	C	09/28/94	09/27/95	N	08/27/95	Covers SWTP Train 2 treatment plant. Construction complete. Engineering Certification not yet sent.

(a) Permit type, O = Operating, C = Construction
(b) Permit extended/renewed? N = No, Y = Yes
QWTP Quarry water treatment plant
SWTP Site water treatment plant
* See Section 3.5

waste ponds (raffinate pits) on site began in 1995 for water control and treatment, resulting in a slight water level decrease.

Topsoils and subsoils from the off-site soils borrow area, which are being stored for restoration, have been stockpiled at the borrow area. Stockpile heights and slopes have been limited to 15 ft (4.6 m) and 3:1. Topsoil stockpiles have been seeded and mulched for erosion control. Erosion control measures have been implemented at the borrow area and haul road area and erosion control inspections have been conducted. One sedimentation pond was constructed at the borrow area in late fall of 1995, but no surface water monitoring was conducted due to lack of significant precipitation. All work areas that were completed and ready for winter shutdown were reseeded and mulched.

During the construction phase at the borrow area, vehicle and equipment mufflers were checked and found to be in good condition. All roadways were routinely sprayed with water for dust control during the active construction period at the borrow area and haul road areas. Public vehicle access is prohibited in the borrow and haul road areas by temporary fencing and/or gates. No hauling of borrow material to the chemical plant proper occurred in 1995.

Air, surface water and groundwater have been monitored as part of the routine environmental monitoring activities at the chemical plant area. Results of on-site monitoring have shown no increased contaminant concentrations as a result of construction activities. Air quality and radon testing averages have been at background levels at monitoring locations at the Francis Howell High School. More information on this monitoring is provided in other sections of this document.

Eligibility surveys for archeological or historic sites at the borrow area or haul road corridor were conducted and no sites were found that would require avoidance or data recovery. Confirmation letters in regard to this decision have been received by the State Historic Preservation Officer.

4 RADIATION AND ASBESTOS MONITORING PROGRAMS

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental monitoring and surveillance program in accordance with U.S. Department of Energy (DOE) Orders and with the *Environmental Monitoring Plan* (Ref. 42). This section describes monitoring results for radon, external gamma radiation, airborne radioactive particulates and asbestos at various site perimeter and off-site locations. A program overview, summary of applicable standards, actual monitoring results, and an assessment of any associated environmental impacts is provided below for each parameter mentioned in the plan.

4.1 Radon Gas Monitoring Program

4.1.1 Program Overview

Both U-238 and Th-232 are naturally occurring radionuclides in soil and rock. Radon gases (i.e., Rn-222 and Rn-220) are naturally occurring radioactive gases found in the uranium and thorium decay series. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 and Th-232 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon is produced at the Weldon Spring site from these natural sources as well as from the contaminated waste materials present at the site.

Airborne radon concentrations fluctuate with both soil conditions and meteorological conditions. The amount of radon that actually enters the atmosphere varies depending on a number of parameters, including radium concentrations in soil, soil moisture content, soil porosity, soil density, and atmospheric pressure. Of these, the moisture content of the soil is the most variable and is primarily responsible for quarterly and annual changes in airborne radon concentrations.

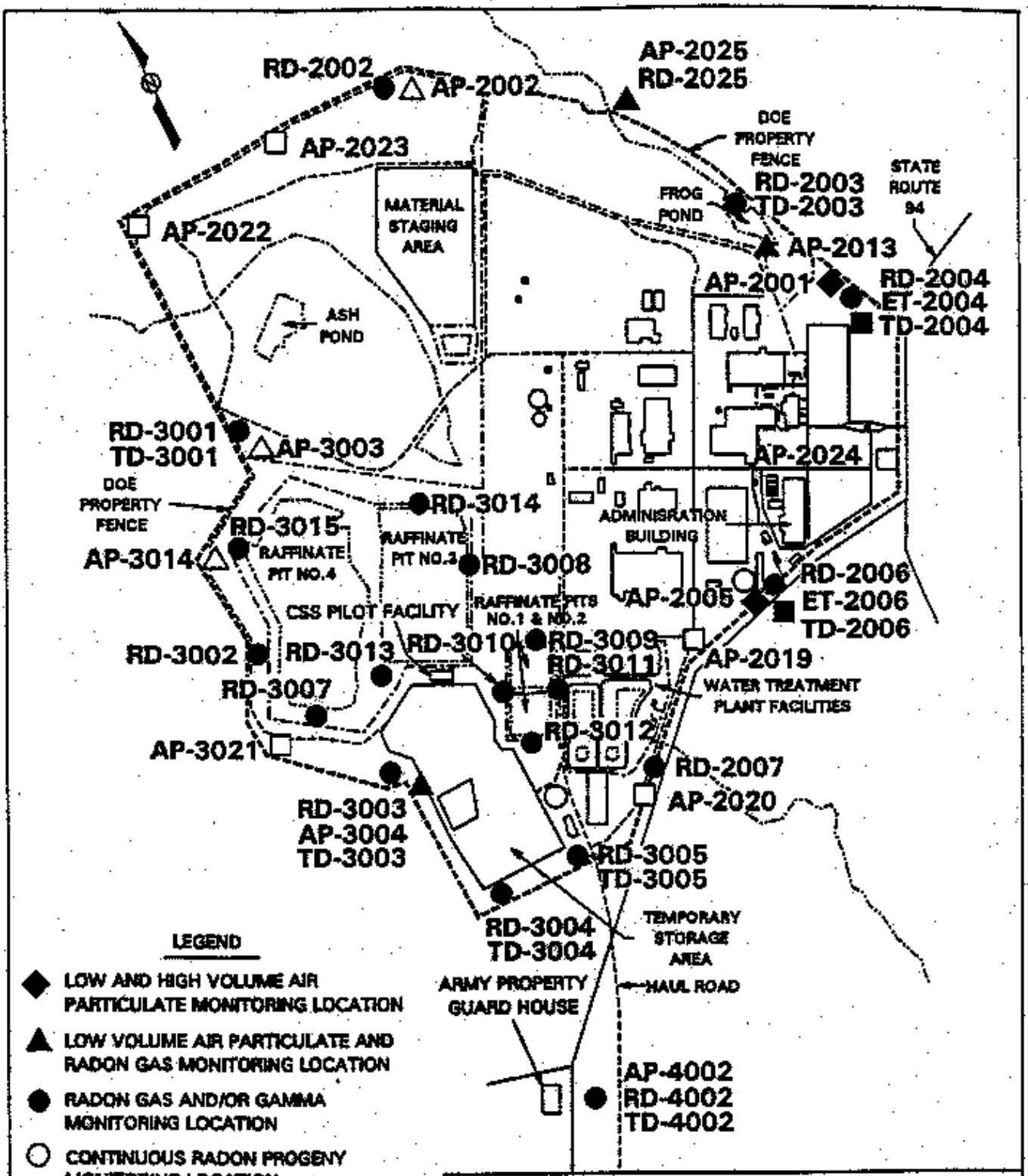
In 1995, a pair of radon track etch detectors was deployed at each of 36 permanent monitoring locations: six at the Weldon Spring Chemical Plant (WSCP) perimeter, seven at the Weldon Spring Quarry (WSQ) perimeter, 14 at the raffinate pits area, two at the chemical stabilization/solidification (CSS) pilot facility, and seven at off-site locations. One pair of detectors was temporarily deployed in the third and fourth quarters of 1995 near Train 2 of the

site water treatment plant. Radon track etch monitoring locations are identified with an "RD" prefix in Figures 4-1, 4-2, 4-3, and 4-4. Monitoring locations adjacent to the CSS pilot facility are identified by ET-3015 and ET-3016 in Figure 4-5. Monitoring locations are distributed around the chemical plant and quarry perimeters to ensure adequate detection of radon under various atmospheric conditions. Locations RD-4005 and RD-4009 monitor background radon concentrations. Alpha track detectors are sensitive to all isotopes of radon and are deployed quarterly.

Modified alpha-track detectors were deployed in 1995 at six monitoring locations: RD-1002, RD-1006, RD-3003, RD-3010, RD-4009 (background station), and ET-3016. These detectors, which filter out Rn-220 (thoron), were placed alongside normal alpha-track monitors to distinguish radon from thoron. Using Pearson's method (Ref. 49), individual concentrations of radon and thoron were calculated for these stations (see Appendix B).

The WSSRAP radon monitoring program also uses electret monitors. Electret monitors provide the means to measure radon gas concentrations in air. Twenty-four pairs of electret monitors that measure Rn-222 only were placed at the following monitoring locations: 18 in the chemical plant/raffinate pits area (including five at the chemical plant perimeters), four at the quarry perimeter, and two off site. Ten pairs of electrets that are used to determine Rn-220 concentrations were deployed at the following locations: five in the vicinity of the raffinate pits, two at the quarry perimeter, one at the chemical plant perimeter (temporary storage area [TSA] fence), and two off site. Electrets are exchanged and read biweekly. These locations, designated by an "ET" prefix, are shown in Figures 4-1 through 4-5.

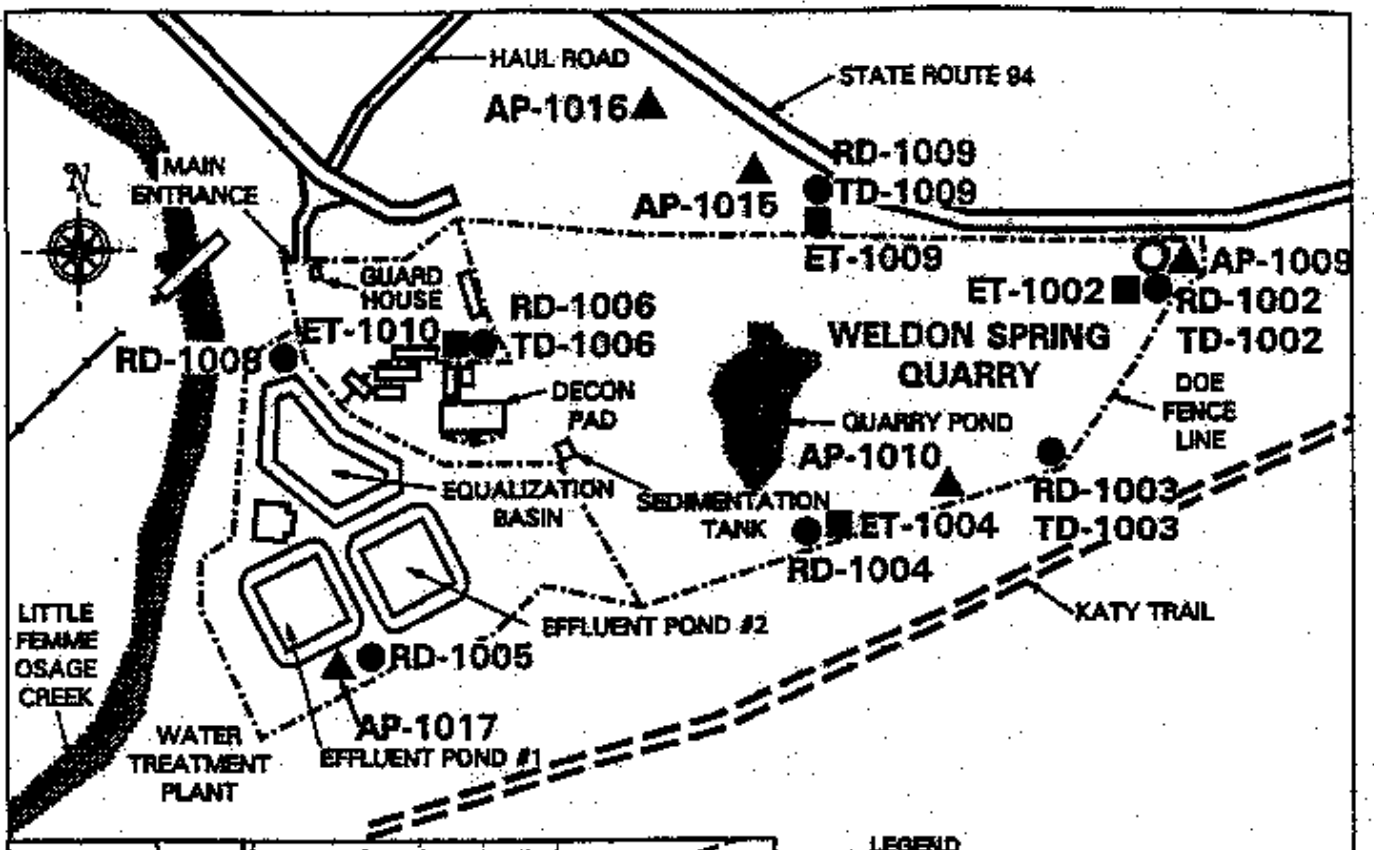
Continuous radon progeny monitors (working level monitors) complete the environmental radon monitoring network. Working level monitors are sensitive to the short-lived decay products of Rn-220 and Rn-222. Results are recorded in milli-working levels (mWL) and are used in work zones in conjunction with radon gas measurements to determine the degree of equilibrium of radon gas with its decay products. The working level monitors operated from January through April at the TSA access control point, quarry trailers, AP-1009, and AP-2005. They were removed for upgrades in late April and were returned to the monitoring network in October.

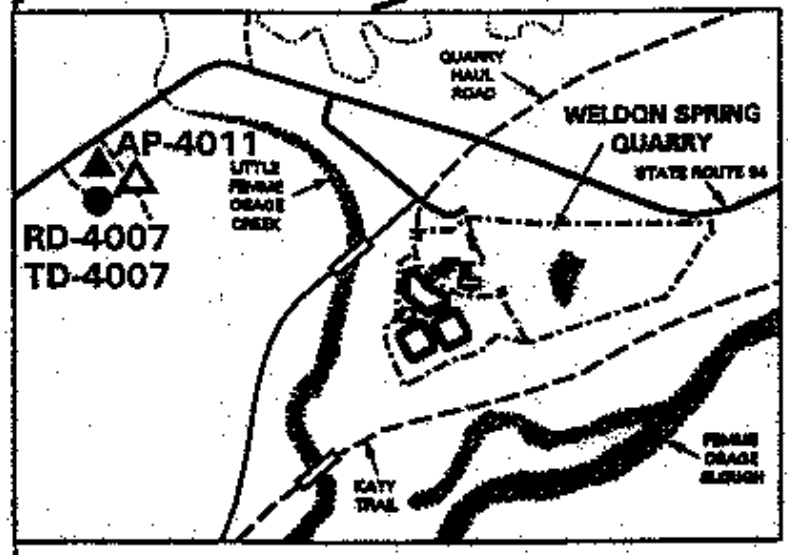


RADON AND AIR PARTICULATE MONITORING LOCATIONS AT THE CHEMICAL PLANT AREA

FIGURE 4-1

REPORT NO.:	DOE/OR/21548-592	BOOK NO.:	A/CP/042/0694
ORIENTATION	MP	DRAWN BY:	GLN
DATE	5/16/96		





LEGEND

- △ HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- ▲ LOW VOLUME AIR PARTICULATE MONITORING LOCATION
- ● RADON GAS AND OR GAMMA RADIATION MONITORING LOCATION
- ○ CONTINUOUS RADON GAS MONITORING LOCATION
- ■ ELECTRET MONITORING LOCATION
- RD RADON GAS MONITORING LOCATION
- TD GAMMA RADIATION MONITORING STATION
- AP AIR PARTICULATE MONITORING STATION
- ET ELECTRET MONITORING STATION

0 300 600 FT

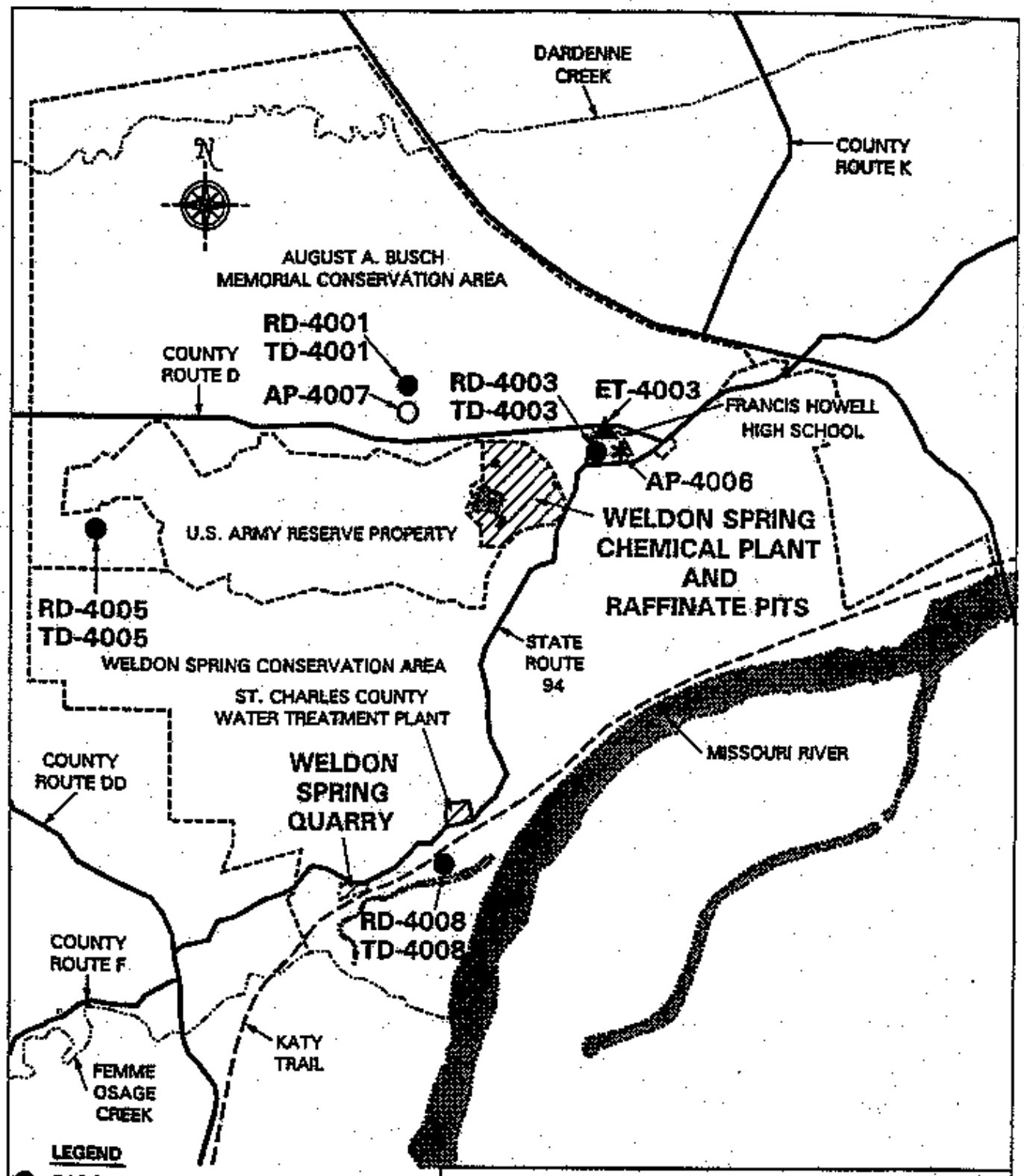
0 91.4 182.8 M

SCALE

AIR MONITORING LOCATIONS AT THE WSQ AREA

FIGURE 4-2

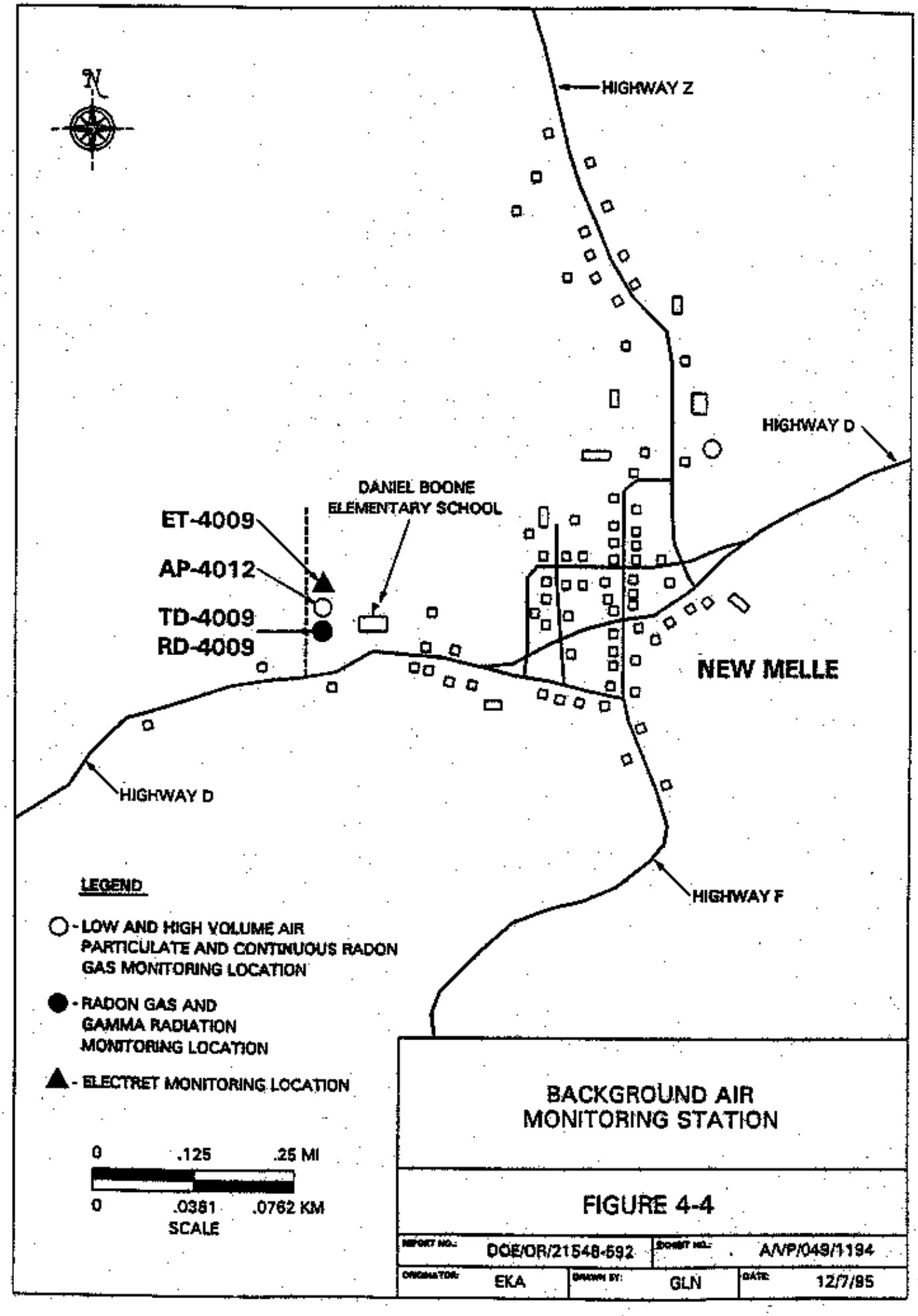
REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/OY/089/1194
ORIGINATOR	EKA	DRAWN BY:	GLN
DATE	5/16/96		

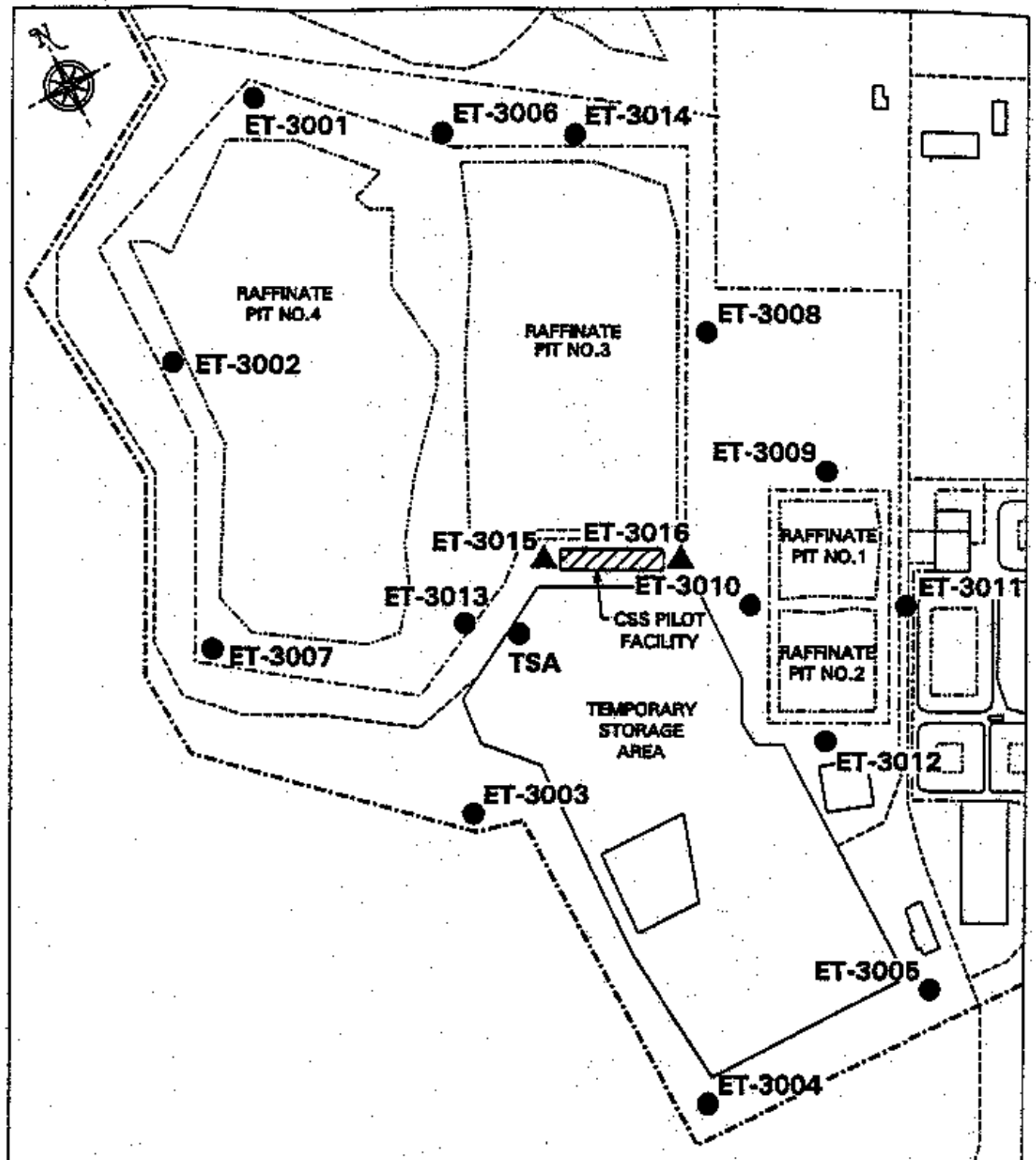


OFF-SITE AIR MONITORING LOCATIONS

FIGURE 4-3

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/VP/048/1194
ORIGINATOR:	EKA	DRAWN BY:	GLN
		DATE:	12/7/95


N
HIGHWAY Z
HIGHWAY D
DANIEL BOONE
ELEMENTARY SCHOOL
ET-4009
AP-4012
TD-4009
RD-4009
NEW MELLE
HIGHWAY D
HIGHWAY F
LEGEND
- LOW AND HIGH VOLUME AIR PARTICULATE AND CONTINUOUS RADON GAS MONITORING LOCATION
- RADON GAS AND GAMMA RADIATION MONITORING LOCATION
- ELECTRET MONITORING LOCATION
0 .125 .25 MI
0 .0381 .0762 KM
SCALE
BACKGROUND AIR MONITORING STATION
FIGURE 4-4
REPORT NO.: DOE/OR/21548-592
DOMET NO.: A/V/P/049/1194
ORIGINATOR: EKA
DRAWN BY: GLN
DATE: 12/7/85



● ELECTRET MONITORING LOCATION

▲ ELECTRET, TRACK ETCH RADON DETECTOR, AND/OR GAMMA MONITORING LOCATION

NOT TO SCALE

ELECTRET MONITORING LOCATIONS AT THE WELDON SPRING RAFFINATE PIT AREA

FIGURE 4-5

REPORT NO.:	DOE/OR/21548-592	DRAWING NO.:	A/RP/010/0694
ORIGINATOR:	MP	DRAWN BY:	GLN
DATE:	5/16/96		

Three new radon progeny monitors were received and deployed on a trail basis in May 1995. These "WLx" monitors report radon and thoron progeny levels separately.

4.1.2 Applicable Standards

The derived concentration guide (DCG) is a limiting airborne concentration of a specified radionuclide. The DCGs are based on a committed effective dose equivalent of 100 mrem/year (1.0 mSv/year) and assume continuous exposure. DOE Order 5400.5 specifies a DCG for both radon and thoron in unrestricted (off-site) areas of 3 pCi/l (111 Bq/m^3) above the background concentration.

4.1.3 Monitoring Results

Table 4-1 summarizes quarterly and annual average integrated radon concentrations as measured by alpha-track detectors. Since radon is naturally occurring, concentrations measured at each monitoring location were compared to measured background concentrations to determine whether any significant differences existed at the 95% confidence level. Only locations with radon concentrations statistically greater than background were compared to the DCG for radon by subtracting the average annual background concentration from the gross annual average concentration measured at each location.

The results obtained from the pair of alpha track detectors at each location were averaged to determine the quarterly average radon concentration. These averages were then used to calculate the annual average radon gas concentration. The annual standard deviation reported reflects the error propagated by taking the standard deviation of the mean of the quarterly results.

The annual alpha track background concentration was calculated using the arithmetic average of the two background locations. The data yielded an annual background average radon concentration in 1995 of 0.3 pCi/l (11 Bq/m^3). The average background radon concentration did not significantly change from previous years' monitoring results.

Based on measurements from modified alpha-track monitors at locations where a combined release of radon and thoron was suspected, thoron concentrations were estimated using

TABLE 4-1 1995 Alpha Track Radon Results[a]

LOCATION I.D.	1ST QUARTER pCi/l[b]	2ND QUARTER pCi/l[b]	3RD QUARTER pCi/l[b]	4TH QUARTER pCi/l[b]	ANNUAL AVERAGE pCi/l[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT [c]	PERCENT OF GUIDELINE[d]
WELDON SPRING QUARRY								
RD-1002	1.6	0.7	0.7	0.6	0.9	0.5	X	20
RD-1003	0.2	0.1	0.4	0.4	0.3	0.2		N/A
RD-1004	0.1	0.1	0.4	0.5	0.3	0.2		N/A
RD-1005	0.1	0.2	0.3	0.4	0.3	0.1		N/A
RD-1006	0.1	0.3	0.5	0.6	0.4	0.2		N/A
RD-1008	0.2	0.2	0.5	0.3	0.3	0.1		N/A
RD-1009	0.1	0.2	0.4	0.6	0.3	0.2		N/A
WELDON SPRING CHEMICAL PLANT								
RD-2002	0.1	0.2	0.3	0.4	0.3	0.1		N/A
RD-2003	0.1	0.2	0.4	0.6	0.3	0.2		N/A
RD-2004	0.1	0.3	0.5	0.4	0.3	0.2		N/A
RD-2006	0.1	0.1	0.3	0.3	0.2	0.1		N/A
RD-2007	0.1	0.1	0.5	0.4	0.4	0.2		N/A
Train 2	--	--	0.3	0.3	0.3	0		N/A
WELDON SPRING RAFFINATE PITS								
RD-3001	0.2	0.2	(e)	0.7	0.4	0.3		N/A
RD-3002	0.1	0.1	--	0.4	0.2	0.2		N/A
RD-3003	0.3	0.8	0.7	0.5	0.6	0.2	X	10
WELDON SPRING RAFFINATE PITS (Continued)								

TABLE 4-1 1995 Alpha Track Radon Results[a] (Continued)

LOCATION I.D.	1ST QUARTER pCi/l[b]	2ND QUARTER pCi/l[b]	3RD QUARTER pCi/l[b]	4TH QUARTER pCi/l[b]	ANNUAL AVERAGE pCi/l[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT [c]	PERCENT OF GUIDELINE[d]
RD-3004	0.1	0.2	0.4	0.5	0.3	0.2		N/A
RD-3005	0.1	0.2	0.6	0.5	0.4	0.2		N/A
RD-3007	0.1	0.3	0.5	0.6	0.4	0.2		N/A
RD-3008	0.1	0.3	0.4	0.4	0.3	0.1		N/A
RD-3009	0.1	0.4	0.4	0.5	0.4	0.2		N/A
RD-3010	0.2	0.6	0.8	0.8	0.6	0.3		N/A
RD-3011	0.1	0.2	0.4	0.6	0.3	0.2		N/A
RD-3012	0.4	0.7	0.7	0.7	0.6	0.2	X	10
RD-3013	0.3	0.7	1.1	1.3	0.9	0.4	X	20
RD-3014	0.2	0.3	0.8	1.3	0.7	0.5		N/A
RD-3015	0.1	0.1	0.4	0.7	0.4	0.3		N/A
CSS PILOT FACILITY								
ET-3015	0.4	0.5	1.3	0.4	0.7	0.4		N/A
ET-3016	0.4	0.4	0.6	0.8	0.6	0.2		N/A
OFF SITE								
RD-4001	0.1	0.2	0.4	0.4	0.3	0.2		N/A
RD-4002	0.1	0.1	0.4	0.3	0.2	0.2		N/A
RD-4003	0.1	0.2	0.4	0.3	0.3	0.1		N/A
OFF SITE (Continued)								

TABLE 4-1 1995 Alpha Track Radon Results[a] (Continued)

LOCATION I.D.	1ST QUARTER pCi/l[b]	2ND QUARTER pCi/l[b]	3RD QUARTER pCi/l[b]	4TH QUARTER pCi/l[b]	ANNUAL AVERAGE pCi/l[b]	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT [c]	PERCENT OF GUIDELINE[d]
*RD-4005	0.1	0.1	0.3	0.4	0.2	0.2		N/A
RD-4007	0.1	0.1	0.4	0.4	0.3	0.2		N/A
RD-4008	0.2	0.4	0.6	0.5	0.4	0.2		N/A
*RD-4009	0.1	0.2	0.4	0.6	0.3	0.2		N/A
RD-4010	0.1	0.2	0.4	0.5	0.3	0.2		N/A

(a) Results include natural background levels except where otherwise noted.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed student's t-test at the 95% confidence level.
(d) Percent of guideline is calculated by taking the annual station average minus the average of the background stations, divided by the DOE concentration guideline for Rn-222 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
(e) Missing alpha track radon monitor.
--- Annual average concentration less than or equal to background.
* Background station.
N/A No percentage calculation performed on background locations or locations not statistically greater than background.

Pearson's method (Ref. 49). Pearson's method is described in Appendix B. Locations with Rn-220 concentrations statistically greater than background at the 95% confidence level were compared with the DCG for thoron. Results are presented in Table 4-2.

Radon concentrations measured by the electret monitors are summarized in Tables 4-3 and 4-4. Because electret results are obtained biweekly rather than quarterly (as with the alpha track detectors), they are used primarily as advance indicators of any trends in radon/thoron levels at a given monitoring location. Alpha track results, rather than electret results, are used in performing off-site dose calculations.

Table 4-5 summarizes average monthly and annual radon progeny levels as recorded by the continuous working level monitors. Typical background radon progeny levels average 2-3 mWL. Results indicate background levels at all monitoring locations.

4.1.4 Data Analysis

Statistical analysis of the alpha track radon detector results indicated that at the 95% confidence level, the measured concentrations at one of the seven monitoring locations at the quarry perimeter were greater than the background monitoring location concentrations. Furthermore, the analysis indicated that measurements from three of the 14 raffinate pit locations and one of the two CSS pilot facility locations were greater than the background station results. The analysis indicates that the results for all other stations were not distinguishable from background levels.

4.1.4.1 Chemical Plant, CSS Pilot Facility, and Raffinate Pits. Statistical analysis of four locations indicated measured results greater than background levels. These stations are located around the raffinate pits perimeter and the CSS pilot facility. The average concentrations for the above monitoring stations exceeded background levels by 0.3 pCi/l (11 Bq/m^3) to 0.6 pCi/l (22 Bq/m^3). These results were anticipated, given the decreasing water levels in Raffinate Pit 4. The quarterly measured radon concentrations from all stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 1.3 pCi/l (48 Bq/m^3).

TABLE 4-2 1995 Thoron Concentrations as Determined Using Modified Alpha-Track Detectors

STATION ID	FIRST QUARTER (pCi/l)[a]	SECOND QUARTER (pCi/l)[a]	THIRD QUARTER (pCi/l)[a]	FOURTH QUARTER (pCi/l)[a]	ANNUAL AVERAGE (pCi/l)	ANNUAL STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (x)	PERCENT OF GUIDELINE[b]
RD-1002	2.5	0.7	0.1	0.2	0.9	1.1		N/A
RD-1006	0.2	0.4	0.1	0.2	0.2	0.1		N/A
RD-3008	0.5	0.8	0.3	0.2	0.5	0.3		N/A
RD-3010	0.4	0.7	0.3	0.7	0.5	0.2	X	10
RD-4009*	0	0.3	0	0.3	0.2	0.2		N/A
ET-3016	–	--	0.2	0	0.1	0.1		N/A

* Background station

(a) To convert from pCi/l to Bq/m^3, multiply by 37.

(b) Percent of guideline is calculated by taking the annual station average minus the annual average of the background station, divided by the DCG for Rn-220 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.

(c) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed student's t-test at the 95% confidence level.

– Measurement not collected.

N/A No percent of guideline calculated for stations not statistically greater than background.

TABLE 4-3 1995 Electret Radon-222 Results[a]

LOCATION I.D.	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
ET-1002	0.43	0.37	0.81	0.48	0.52	0.20
ET-1004	0.48	0.40	0.70	0.65	0.56	0.14
ET-1009	0.28	0.88	0.54	0.63	0.58	0.25
ET-1010	0.58	0.38	0.80	0.80	0.64	0.20
ET-2004	0.48	0.70	0.96	0.48	0.65	0.23
ET-2006	0.38	0.56	0.57	0.60	0.53	0.10
ET-3001	0.46	0.42	1.07	0.58	0.63	0.30
ET-3002	0.40	0.46	0.87	0.63	0.59	0.21
ET-3003	0.50	0.38	0.66	0.43	0.49	0.12
ET-3004	0.35	0.28	0.61	0.60	0.46	0.17
ET-3005	0.36	0.50	0.81	0.43	0.52	0.20
ET-3006	0.47	0.33	0.63	0.45	0.47	0.12
ET-3007	0.40	0.40	0.47	0.68	0.49	0.13
ET-3008	0.40	0.67	0.83	0.75	0.66	0.19
ET-3009	0.50	0.25	1.39	0.83	0.74	0.49
ET-3010	0.95	0.53	0.71	0.95	0.79	0.20
ET-3011	0.46	0.70	0.76	0.78	0.67	0.15
ET-3012	0.38	0.52	0.63	0.48	0.50	0.10
ET-3013	0.35	0.40	0.76	0.48	0.50	0.18
ET-3014	0.36	0.33	0.81	0.73	0.56	0.25
ET-3015	0.59	0.36	1.21	0.83	0.75	0.36
ET-3016	0.39	0.33	0.54	0.45	0.43	0.09
ET-4003	0.58	0.70	0.87	0.55	0.68	0.15
ET-4009*	0.37	0.43	0.69	0.45	0.49	0.14

(a) Results include natural background levels.

TABLE 4-3 1995 Electret Radon-222 Results (Continued)

(b) To convert from pCi/l to Bq/m^3, multiply by 37.
* Background station.

TABLE 4-4 1995 Electret Radon-220 Results[a]

LOCATION I.D.	1ST QUARTER (pCi/l)[b]	2ND QUARTER (pCi/l)[b]	3RD QUARTER (pCi/l)[b]	4TH QUARTER (pCi/l)[b]	ANNUAL AVERAGE (pCi/l)[b]	ANNUAL STANDARD DEVIATION
ET-1002	2.17	1.27	1.23	0.78	1.36	0.58
ET-1010	0.58	0.53	0.58	0.55	0.56	0.02
ET-3006	1.73	1.08	1.67	0.97	1.36	0.39
ET-3010	0.47	0.73	0.98	0.60	0.70	0.22
ET-3013	3.17	1.30	1.69	1.60	1.94	0.84
ET-3015	0.50	0.73	1.21	1.65	1.02	0.51
ET-3016	1.13	0.66	1.25	0.83	0.97	0.27
ET-4003	--	0.10	0.26	0.73	0.36	0.33
ET-4009*	--	0.13	0.17	0.50	0.27	0.20
TSA Fence	--	--	--	1.25	1.25	--

(a) Results include natural background levels.
(b) To convert from pCi/l to Bq/m^3, multiply by 37.
* Background station.
-- Measurement not collected.

TABLE 4-5 1995 Working Level Measurements

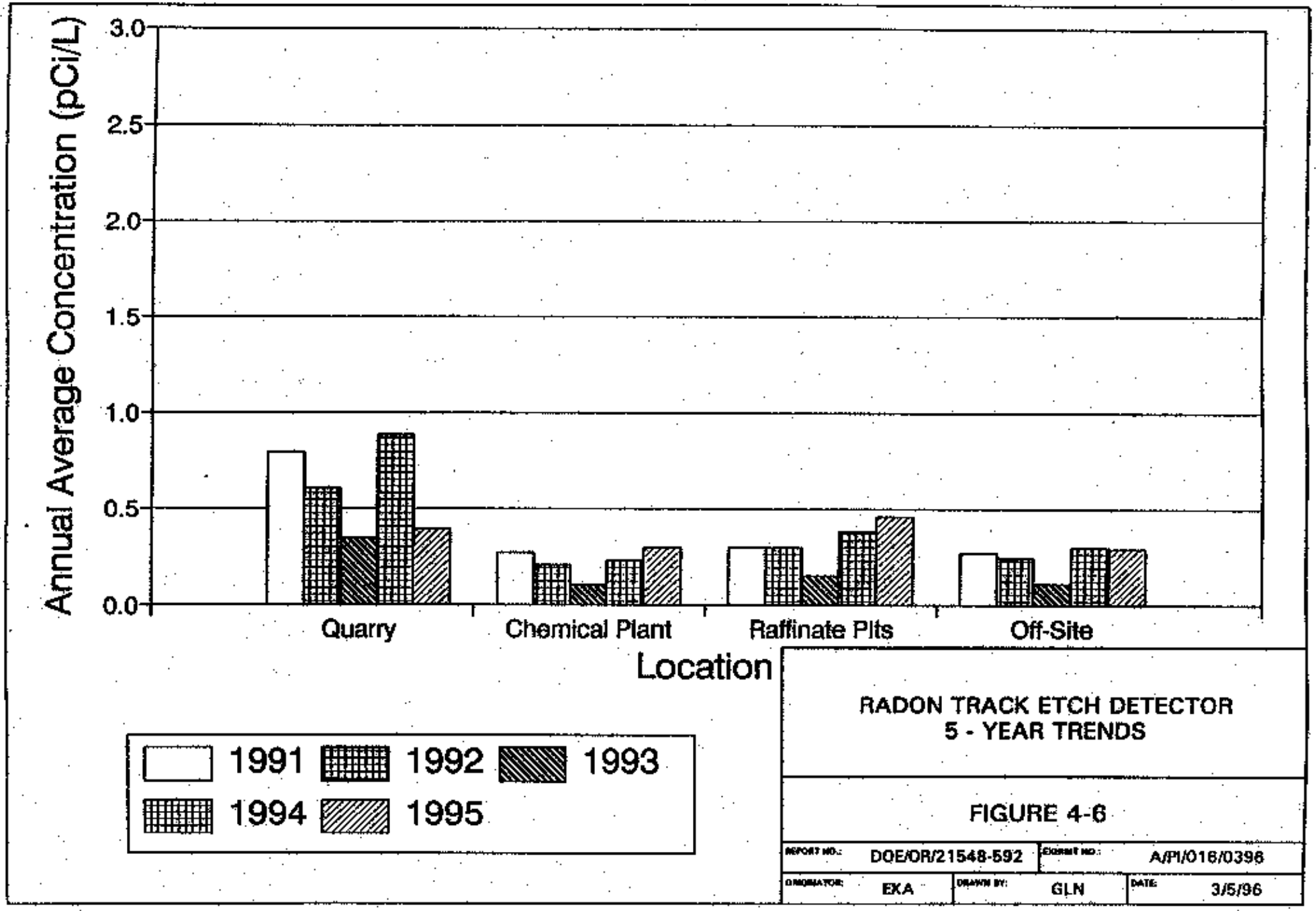
LOCATION	AVERAGE WORKING LEVEL MEASUREMENT (mWL)												ANNUAL AVERAGE (mWL)
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
TSA Access	0.2	0.1	0.4	1.5	--	--	--	--	--	2.5	11.8	2.0	2.6
Quarry Trailers	0.7	1.1	1.5	1.5	--	--	--	--	--	--	3.8	3.7	2.1
AP-1009	1.7	1.4	--	1.3	--	--	--	--	--	2.5	--	--	1.7
AP-2005	1.2	0.8	0.5	1.2	--	--	--	--	--	--	--	2.6	1.3

-- Measurement not collected.

4.1.4.2 Quarry. Statistical analysis of location RD-1002 indicated measured results greater than background levels. These results were not unexpected, because radium-containing quarry bulk waste was removed during the year. Furthermore, the quarry is surrounded by steep walls that tend to stagnate the air inside it. This inhibits dispersion and results in an increased concentration at the quarry upper rim. The quarterly measured results for all quarry stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 1.6 pCi/l (59 Bq/m^3).

4.1.4.3 Off Site. Statistical analysis of monitoring results from off-site locations indicated that there was no reason to suspect at the 95% confidence level that measured concentrations at any of the stations were greater than background levels. The quarterly radon concentration measurements at off-site locations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.6 pCi/l (22 Bq/m^3). These results are similar to results obtained during previous years.

4.1.4.4 Five Year Trend Analysis of Radon Gas. Figure 4-6 shows 5 years of annual average alpha track radon concentrations for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. These monitoring results include natural background radon concentrations. No significant trends are evident; however, radon gas levels at the quarry dropped notably from 1994 to 1995.



RADON TRACK ETCH DETECTOR
5 - YEAR TRENDS

FIGURE 4-6

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/PI/016/0396		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	3/5/96

4.2 Gamma Radiation Monitoring

4.2.1 Program Overview

Gamma radiation is emitted from natural, cosmic, and manmade sources. The earth naturally contains gamma radiation-emitting substances, such as uranium, thorium, and potassium (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise natural background radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (Ref. 33) estimates the typical gamma radiation dose is 35 mrem/year (0.35 mSv/year) from the earth and 30 mrem/year (0.30 mSv/year) from cosmic sources. The total estimated background radiation dose equivalent for this area due to gamma exposure is 65 mrem/year (0.65 mSv/year).

Gamma radiation is monitored at the site using environmental thermoluminescent dosimeters (TLDs) at 19 monitoring stations: three at the site perimeter, four along the site perimeter near the raffinate pits, four along the quarry perimeter, and seven off site. The locations are denoted by a "TD" prefix on Figures 4-1, 4-2, 4-3, and 4-4. TLDs were also placed at ET-3015 as shown on Figure 4-5. Stations TD-4005 and TD-4009 measure natural background at locations unaffected by the site. The TLDs are changed out every quarter.

4.2.2 Applicable Standards

No specific standard for gamma radiation is stated in the DOE orders; however, DOE Order 5400.5 specifies that members of the public shall receive less than 100 mrem/year (1.0 mSv/year) from DOE operations for all exposure pathways.

4.2.3 Monitoring Results

Table 4-6 summarizes quarterly and annual average gamma radiation monitoring results. The table includes quarterly averages, annual totals, the annual sample standard deviation for each station, and whether a station's annual monitoring results are statistically distinguishable at the 95% confidence level, from background levels as determined by a one-tailed student's t-test. The standard deviations reported reflect the error propagated by taking into account the standard deviation of the mean of each quarterly result.

TABLE 4-6 1995 Environmental TLD Results[a]

LOCATION	1ST QUARTER (mrem)[c]	2ND QUARTER (mrem)[c]	3RD QUARTER (mrem)[c]	4TH QUARTER (mrem)[c]	ANNUAL TOTAL (mrem/yr)[c]	STANDARD DEVIATION	STATISTICALLY SIGNIFICANT (X)[d]
WELDON SPRING QUARRY							
TD-1002	19	14	15	17	65	2	
TD-1003	23	17	17	20	77	3	X
TD-1006	18	14	14	17	63	2	
TD-1009	17	13	14	16	60	2	
WELDON SPRING CHEMICAL PLANT							
TD-2003[b]	21	15	17	--	71	2	
TD-2004	19	15	16	19	69	2	
TD-2006	19	15	16	20	70	2	
WELDON SPRING RAFFINATE PITS							
TD-3001	18	14	18	19	69	2	
TD-3003	22	16	19	21	78	3	X
TD-3004	18	14	16	18	66	2	
TD-3005[b]	--	17	21	21	79	2	
ET-3015[b]	15	16	--	20	68	2	
OFF SITE							
TD-4001	18	15	17	18	68	2	
TD-4002	15	12	13	17	57	2	
TD-4003	14	11	13	15	53	2	
*TD-4005	17	13	15	16	61	2	
TD-4007	17	13	15	17	62	2	
TD-4008	22	11	15	21	69	5	
*TD-4009	17	13	15	17	62	2	

* Denotes background location.

(a) Results include natural background gamma radiation.

(b) To calculate the annual total, missing data were replaced with the average of the remaining quarterly results for a given station.

(c) To convert from mrem to mSv, divide by 100.

(d) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the annual background average concentration, using a one-tailed student's t-test at the 95% confidence level.

-- No measurement taken due to lost or damaged TLD.

Gamma background levels for 1995 were determined by averaging the quarterly measurements from the two background stations. The annual average result from these stations was 61 mrem/year (0.61 mSv) with a standard deviation of 3 mrem/year (0.03 mSv). This average background is comparable to the UNSCEAR 1982 estimate of 65 mrem/year (0.65 mSv/year) (Ref. 33).

4.2.4 Data Analysis

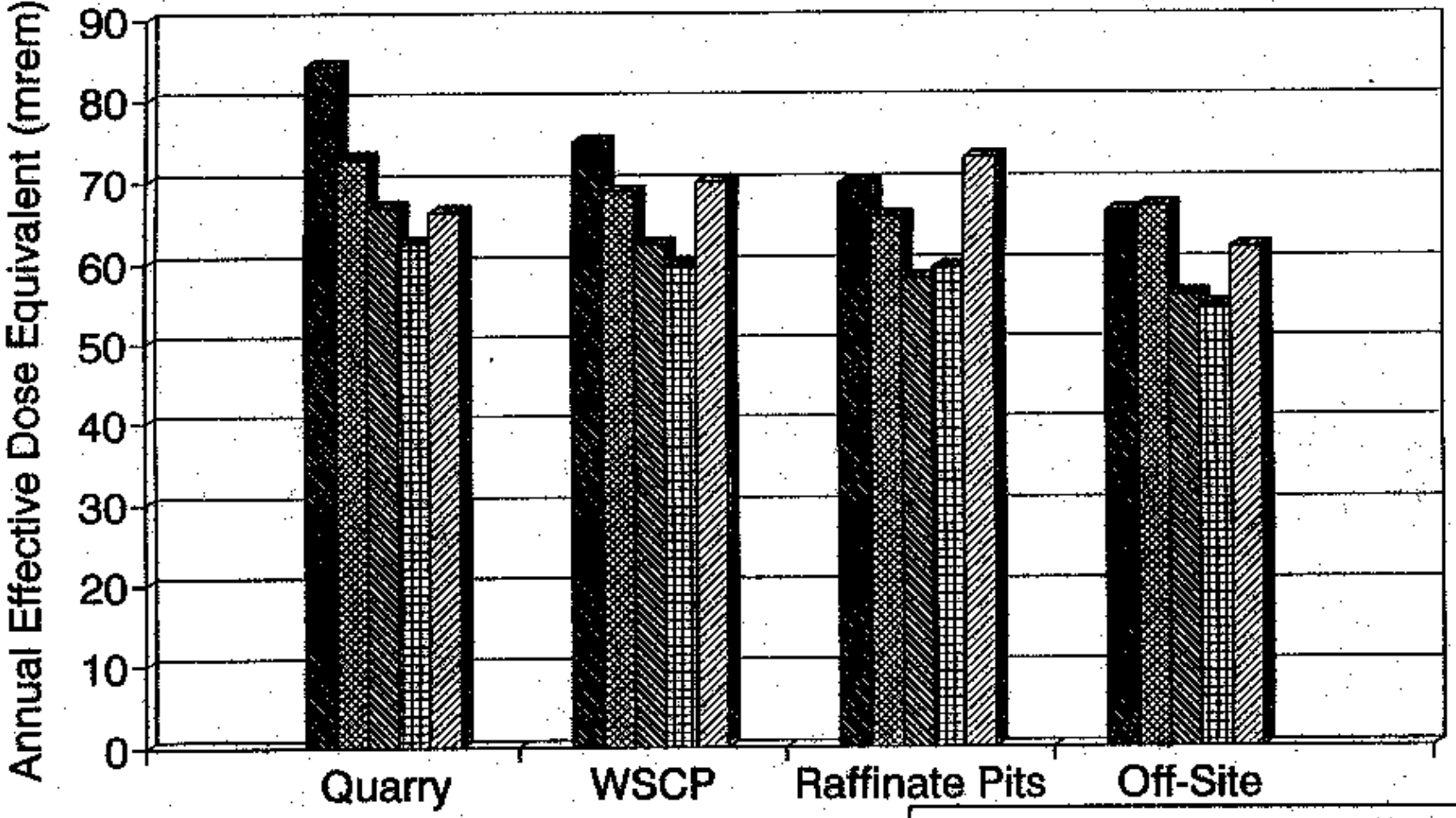
Statistical analysis of TLD results revealed that, at the 95% confidence level, stations TD-1003 (quarry) and TD-3003 (TSA) had annual results greater than background levels. The analysis further revealed that all other stations were indistinguishable from background levels.

4.2.4.1 Chemical Plant/Raffinate Pits. The annual total gamma radiation measurements from TLDs at the chemical plant and raffinate pits ranged from 66 mrem (0.66 mSv) to 79 mrem (0.79 mSv). This range of results is generally higher than previous years for these areas due to quarry bulk waste storage at the TSA and dewatering of Raffinate Pit 4.

4.2.4.2 Quarry. The annual total gamma radiation measurements from TLDs at the quarry ranged from 60 mrem (0.60 mSv) to 77 mrem (0.77 mSv). These results are comparable to previous years for this area.

4.2.4.3 Off-Site. The annual total gamma radiation measurements from TLDs at off-site locations ranged from 53 mrem (0.53 mSv) to 69 mrem (0.69 mSv). These results are comparable to previous years for these areas.

4.2.4.4 Five Year Trend Analysis of TLDs. Gamma radiation exposure monitoring results for the last five years are shown graphically in Figure 4-7. The graph shows yearly monitoring result totals for the chemical plant, raffinate pits, quarry, and off-site locations. The results include the natural background dose rate. Results indicate increases at the chemical plant and raffinate pits. These increases are explained in Section 4.2.4.1 above. No other trends are evident.



ENVIRONMENTAL TLD
5 - YEAR TRENDS

FIGURE 4-7

REPORT NO.:	DOE/OR/21548-592	DWG# NO.:	A/PI/017/0396		
ORIGINATOR:	EKA	DRAWN BY:	GLN	DATE:	3/5/96

4.3 Radioactive Air Particulate Monitoring

4.3.1 Program Overview

Radioactive air particulates are airborne dust particles that contain radioactive contaminants. Background concentrations of radioactive air particulates are affected by the amount of contaminants in the soil, moisture, atmospheric dispersion, and geological conditions. Many areas on site contain above background concentrations of soil contamination, which can result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emissions from the site can result from wind erosion or remedial work activities, such as moving equipment and vehicles in contaminated areas.

The WSSRAP monitors radioactive air particulates weekly using 17 continuous permanent low volume air samplers: seven at the site perimeter, five at the quarry, and at five off-site locations. These locations are denoted by an "AP" prefix on Figures 4-1, 4-2, 4-3, and 4-4. In addition, six temporary low-volume air monitoring stations are deployed around the chemical plant perimeter. These portable air particulate samplers are deployed at temporary stations when current activities warrant their use. The low volume samplers collect airborne particulates by drawing ambient air through mixed cellulose ester filters with a 0.80 micron pore size. The filters are then analyzed on a gas flow proportional counter to determine the amount of long-lived gross alpha activity in the particulates present on the filter surface.

4.3.2 Applicable Standards

The DCGs for inhalation of various radioactive air particulates are specified in Chapter III of DOE Order 5400.5.

4.3.3 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 17 permanent and two temporary low volume stations are summarized in Table 4-7. Annual averages were calculated using uncensored weekly air particulate analysis results. Uncensored data refers to all results, including those near or below the minimum detectable concentration (MDC). The DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and*

TABLE 4-7 1995 Radioactive Air Particulate Gross Alpha Results

MONITORING STATION IDENTIFICATION NUMBER	ANNUAL AVERAGE LONG-LIVED GROSS ALPHA CONCENTRATION (x1E-15 μCi/ml)[b]	STANDARD DEVIATION (x1E-15 μCi/ml)	NUMBER OF SAMPLE VALUES ABOVE MDC[c]/TOTAL NUMBER OF SAMPLES	STATISTICALLY SIGNIFICANT (X)[a]
AP-2001	1.42	0.533	52/52	
AP-2002	1.37	0.594	48/48	
AP-3003	1.30	0.605	50/50	
AP-3004	1.45	0.522	52/52	X
AP-2005	1.21	0.407	52/52	
AP-4006	1.36	0.578	49/52	
AP-4007	1.42	0.570	50/52	
AP-4008	1.44	0.681	51/52	
AP-1009	1.99	0.133	52/52	X
AP-1010	1.57	0.676	52/52	X
AP-4011	1.41	0.595	50/52	
AP-4012[a]	1.28	0.528	50/50	
AP-2013[d]	1.48	0.885	17/18	
AP-3014	1.26	0.637	49/51	
AP-1015	1.62	0.729	52/52	X
AP-1016	1.45	0.544	52/52	
AP-1017	1.40	0.585	50/52	
AP-2025[d]	1.42	0.672	33/33	

(a) Indicates background monitoring station. Background concentration is a 2-year average.
(b) The annual average gross alpha concentrations were calculated using uncensored data, which includes results less than reported minimum detectable concentrations.
(c) MDC - minimum detectable concentration.
Multiply by 37,000 to convert μCi/ml to Bq/ml
(d) Station AP-2013 was replaced with AP-2025 during 1995.

TABLE 4-7 1995 Radioactive Air Particulate Gross Alpha Results (Continued)

(e) Statistical significance is determined by comparing the annual average concentration for a monitoring location with the 2-year (104-week) background average concentration, using a one-tailed student's t-test at the 95% confidence level.

Environmental Surveillance (Ref. 1) requires the use of uncensored data to minimize any bias in arithmetic averages and standard deviation calculations.

The typical MDC for low volume air particulate sampling at the WSSRAP is 3.3E-16 μCi/ml (1.2E-11 Bq/ml). This MDC is low enough to allow detection of Th-232, which has the lowest DCG at the site of 7.0E-15 μCi/ml (2.6E-10 Bq/ml) (DOE 5400.5). If an individual inhales airborne contaminants at the DCG for one year, the resulting committed effective dose equivalent is 100 mrem (1 mSv).

4.3.4 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that radioactive particulate concentrations exceeded background levels at chemical plant/raffinate pit station AP-3004, and at quarry stations AP-1009, AP-1010, and AP-1015. The quarry stations have historically been above background during bulk waste excavation. Statistical analysis further indicated no reason to suspect that results at any of the other stations were greater than background levels. Background Station AP-4012 had a 104-week average of 1.28E-15 μCi/ml. Exceedance of background levels at AP-3004 is probably due to TSA waste placement, while the levels at the quarry are likely due to quarry bulk waste excavation.

4.3.4.1 Chemical Plant/Raffinate Pits. The average concentrations at the chemical plant/raffinate pits perimeter ranged from 1.21E-15 μCi/ml (4.48E-11 Bq/ml) to 1.48E-15 μCi/ml (5.48E-11 Bq/ml). These results are comparable to those measured in 1994.

4.3.4.2 Quarry. The average concentrations at the quarry perimeter ranged from 1.40E-15 μCi/ml (5.18E-11 Bq/ml) to 1.99E-15 μCi/ml (7.36E-11 Bq/ml). These results are comparable to those measured during 1994.

4.3.4.3 Off-Site. The average concentrations at off-site locations ranged from 1.21E-15 μCi/ml (4.48E-11 Bq/ml) to 1.44E-15 μCi/ml (5.33E-11 Bq/ml). These results are similar to those measured during previous years.

4.4 Radioactive Contamination Control Monitoring

4.4.1 Program Overview

The unrestricted area radioactive contamination control monitoring program ensures that areas used by the general public are not contaminated by radioactive materials migrating from the site as a result of remedial activities. Monitoring consists of in situ measurements (fixed contamination) and swipe sample (removable contamination) collection.

The unrestricted area radioactive contamination control monitoring program includes radiological surveys in both the controlled and uncontrolled areas at the site. Site roadways and the quarry bulk waste haul road are monitored to ensure that removable contamination is kept from these accessible areas.

During 1995, 10 roadway areas outside the site controlled areas were routinely surveyed. Periodic contamination surveys were also conducted at 30 locations along the quarry bulk waste haul road. These surveys continue to confirm that radioactive contamination has not been carried into unrestricted areas.

Direct survey in situ measurements are made with a beta-gamma detector or alpha scintillation detector. One-minute measurements are collected to provide the total (removable plus fixed) radioactivity within the tested area. If the total radioactivity measurement is greater than the most conservative DOE radiological limit for removable activity (20 dpm/100 cm^2) for the radioactive constituents present on-site, then a swipe is taken at that location. The swipe is wiped over an approximate area of 100 cm^2 (15.5 $in.^2$), using a dry cloth or paper swipe. The swipe is analyzed using an alpha scintillation detector. The count rates are corrected to account for detector efficiency and background measurements, and the removable radioactivity is reported in dpm/100 cm^2.

4.4.2 Monitoring Results

The site roadway surveys indicated an annual removable average alpha radioactivity level for all monitoring locations of <4 dpm/100 cm^2. The highest level was 5 dpm/100 cm^2. The average minimum detectable activity (MDA) for alpha radioactivity was 4 dpm/100 cm^2. The roadway surveys indicated an annual average total alpha radioactivity level for all monitoring locations of <11 dpm/100 cm^2; the highest level was 30 dpm/100 cm^2. The average MDA for fixed alpha radioactivity was 11 dpm/100 cm^2.

The 1995 haul road surveys indicated a range of beta-gamma radioactivity of <458 dpm/100 cm^2 to 642 dpm/100 cm^2, with an average of <547 dpm/100 cm^2. The average MDA for beta-gamma radioactivity was 547 dpm/100 cm^2. Most measurements were below the MDA. The annual averages are based upon actual results, whether negative, positive, or zero.

4.4.3 Data Analysis

The site monitoring results show fixed contamination present in a few locations, but at levels well below the DOE uranium surface contamination guidelines for unrestricted use (5,000 dpm/100 cm^2). The contamination was probably caused by airborne uranium deposits that occurred during the operational period of the Weldon Spring Uranium Feed Material Plant. Virtually no removable contamination was found. No increase in removable contamination levels has been measured since the monitoring program was initiated.

The quarry haul road monitoring results indicate background radiation levels. These data indicate that no contamination from the quarry is migrating to the quarry haul road, and thus, there is no identifiable probability for radiological contamination of users of the haul road.

4.5 Airborne Asbestos Monitoring

During 1995, environmental monitoring for asbestos was conducted at Francis Howell High School (AP-4006), at the Weldon Spring site perimeter (AP-2002, AP-2005, AP-2013, AP-3004, and AP-3014), and at the Weldon Spring quarry perimeter (AP-1009, AP-1010, AP-1026, and AP-1016). These locations are identified in Figures 4-1, 4-2, and 4-3. Filters were collected weekly and shipped off-site for analysis.

Two methods are used to analyze asbestos samples. Phased contrast microscopy (PCM) indicates fibers that have the same general size and shape as asbestos; however, this method does not distinguish between asbestos and nonasbestos fibers. Transmission electron microscopy (TEM) measures actual asbestos fiber concentrations. If a PCM measurement indicates a concentration above the site environmental action level (0.01 fibers per milliliter of air), the sample is then resubmitted to the off-site laboratory for TEM analysis.

The results of environmental samples collected at Francis Howell High School and the site and quarry perimeters are provided in Table 4-8. A total of 339 PCM samples were

TABLE 4-8 Summary of Asbestos Air Monitoring Results

LOCATION	NUMBER OF SAMPLES/SAMPLES ABOVE DETECTION LIMIT	RANGE[a]	AVERAGE[a] (f/ml)
AP-2002	47/42	0-0.008	0.002
AP-2005	49/39	0-0.007	0.001
AP-2013	11/10	0.001-0.003	0.002
AP-3004	50/48	0-0.004	0.001
AP-3014	11/10	0.001-0.002	0.001
AP-1009	34/33	0-0.014*	0.002
AP-1010	44/40	0-0.006	0.002
AP-1016	11/10	0.001-0.003	0.001
AP-1026	33/32	0-0.019*	0.003
AP-4006	49/39	0-0.026*	0.002

* At least one sample resubmitted for TEM analysis.
(a) Includes only samples above detection limits.

collected with 303 samples indicating results above the detection limits. The range of samples above the detection limit was 0.001 fibers per milliliter of air (f/ml) to 0.026 f/ml. All samples but one that were resubmitted for TEM analysis were determined to have asbestos concentrations

below detection limits. The one TEM sample indicating detectable asbestos was collected in August at Francis Howell High School. Results showed one actinolite-tremolite fiber on the sample filter, resulting in an asbestos concentration of 0.0005 f/ml.

Both PCM and TEM results of the environmental air samples collected from the site and quarry perimeters and Francis Howell High School are below the fiber concentration limits defined by the EPA's acceptable clearance levels for schools. These results indicate that asbestos fibers were effectively contained during the year.

4.6 Highlights

- Statistical analysis at the 95% confidence level indicated that one radon track-etch monitoring station at the quarry perimeter and four stations in the chemical plant/raffinate pits area exceeded annual average background levels in 1995. The highest measured radon levels were 20% of the DOE derived concentration guide (DCG) for integrated radon (Rn-222 and Rn-220).

- 1995 TLD results for the chemical plant perimeter, quarry perimeter, and off-site locations ranged from 53 mrem/yr (0.53 mSv/yr) to 79 mrem/yr (0.79 mSv/yr). Statistical analysis of the results indicate at the 95% confidence level that one quarry station and one raffinate pit perimeter station exceeded background levels.

- Asbestos analyses performed during 1995 showed fiber concentrations at all monitoring locations to be in compliance with the U.S. Environmental Protection Agency (EPA) acceptable clearance levels for schools.

- Statistical analysis at the 95% confidence level indicated that four low volume airborne particulate monitoring stations exceeded 2-year background averages. These include one at the chemical plant/TSA perimeter and three at the quarry perimeter.

5 RADIATION DOSE ANALYSIS

This section evaluates the effects of atmospheric releases and surface and groundwater discharges of radiological contaminants from the Weldon Spring Site Remedial Action Project (WSSRAP). Potential annual dose equivalents to the general public have been calculated and are presented here. These calculations are compared against U.S. Department of Energy (DOE) guidelines contained in DOE Order 5400.5.

Dose calculations are presented in this section for a maximally exposed individual and a collective population. The exposure conditions used in the dose calculations are further discussed in respective environmental monitoring sections of this report.

Dose calculations related to airborne emissions as required by 40 CFR 61, Subpart H *(National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities)* are presented in Section 6, National Emission Standards for Hazardous Air Pollutants (NESHAPs) Program.

5.1 Pathway Analysis

In developing specific elements of the WSSRAP environmental monitoring program, potential exposure pathways and health effects of the radioactive and chemical materials present on site are reviewed annually to determine which pathways are complete. As required by DOE Order 5400.1, evaluation of each exposure pathway is based on the sources, release mechanisms, types and probable environmental fates of contaminants; and the locations and activities of potential receptors. Pathways are then reviewed to determine whether a link exists between one or more contaminant sources, or between one or more environmental transport processes, to an exposure point where human or ecological receptors are present. If it is determined that a link exists, the pathway is termed complete. Complete pathways are used in assessing radiological and nonradiological exposures. Each complete pathway is reviewed to determine whether a potential for exposure was present during the time frame of concern. If this is the case, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 5-1 lists the six complete pathways for exposure from contaminants evaluated by the WSSRAP environmental monitoring program. These pathways are used to determine

radiological and nonradiological exposures from the site. Of the six complete pathways, five were applicable in 1995 and were thus incorporated into dose estimates. These are Liquid (B), Liquid (C), Airborne (A), Airborne (B), and External.

TABLE 5-1 Exposure Pathways for the Weldon Spring Site

EXPOSURE PATHWAY	PATHWAY DESCRIPTION	APPLICABLE TO 1995 DOSE ESTIMATE
Liquid(A)	Ingestion of groundwater from local wells downgradient from the site.	N
Liquid(B)	Ingestion of game and fish inhabiting wildlife area.	Y
Liquid(C)	Ingestion of surface water and sediments.	Y
Airborne(A)	Inhalation of particulates dispersed through wind erosion and remedial action.	Y
Airborne(B)	Inhalation of radon emitted from contaminated soils/wastes.	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y

As shown in Table 5-1, the Liquid (A) pathway is not applicable to the 1995 dose estimate for the WSSRAP. Concentrations of radioactive contaminants in the production wells near the Weldon Spring Quarry are currently comparable to background concentrations (see Section 8.4). In addition, no drinking water wells are located in the vicinity of the chemical plant/raffinate pits area.

The applicable radiological public dose guidelines for the WSSRAP are as follows:

- NESHAPs standard of 10 mrem (0.10 mSv) total effective dose equivalent annually for airborne emissions other than radon at critical receptor locations.

- DOE guideline of 100 mrem (1 mSv) total effective dose equivalent for all exposure pathways on an annual basis.

5.2 Radiological Release Estimates

Estimates of radiological releases to air and surface water were calculated for radioactive particulates and radon gas. Table 5-2 shows the estimated activity release of radionuclides to the environment, the corresponding mass released, and the half-life for each radionuclide.

Airborne particulate release estimates were calculated based on low volume monitoring results at one perimeter receptor located at the chemical plant perimeter, and one monitoring station at the Weldon Spring Quarry. Box models were used to predict the airborne particulate release rate from the chemical plant and the quarry. The assumptions used in estimating airborne releases are shown in Appendix B.

Box models were also used to predict the radon release rate from the chemical plant and the quarry for the year. In 1995, the estimated Rn-222 release was 15 Ci (5.6E-11 Bq). The estimated Rn-220 release was 3.3 Ci (1.2E-11 Bq). Calculations and assumptions are provided in Appendix B.

During 1995, intermittent surface water runoff transported uranium from the site through six major discharge routes. These routes were monitored through monthly sampling of the runoff water, as required under the site National Pollutant Discharge Elimination System (NPDES) permit (see Section 7). Using NPDES natural uranium values in conjunction with the activity ratios listed above, the U-234, U-235, and U-238 releases to water were calculated and are presented in Table 5-2. Other radionuclides were not routinely monitored in surface water during 1995 because previous monitoring indicated no above background concentrations.

5.3 Exposure Scenarios

Dose calculations were performed for the maximally exposed individual, collective population, and NESHAPs critical receptors for applicable exposure pathways (Table 5-1) to assess dose from the Weldon Spring site. First, conditions were set to determine the total effective dose equivalent to a maximally exposed individual at each of the main site areas: the

TABLE 5-2 Radionuclide Emissions to the Environment

RADIONUCLIDE	ACTIVITY OF RADIONUCLIDE RELEASED TO AIR (Ci)	ACTIVITY OF RADIONUCLIDE RELEASED TO WATER (Ci)	MASS OF RADIONUCLIDE RELEASED (grams)	HALF-LIFE (Yrs)
U-238	2.8E-6	1.3E-2	3.9E4	4.47E09
U-235	1.3E-7	6.1E-4	280	7.04E08
U-234	3.0E-6	1.3E-2	2	2.46E05
Th-232	1.5E-6	N/A	14	1.40E10
Th-230	3.2E-5	N/A	1.6E-3	7.54E04
Th-228	9.5E-7	N/A	1.1E-9	1.91
Ra-228	1.7E-6	N/A	6.2E-9	5.76
Ra-226	2.2E-6	N/A	2.2E-6	1,600
Rn-222	15	N/A	N/A	3.82 days
Rn-220	3.3	N/A	N/A	55.6 seconds
Total Activity	18.3	2.7E-2	3.9E4	N/A

N/A Not analyzed for this radionuclide
-- Not distinguishable from background
Multiply by 3.7E10 to convert Ci to Bq

chemical plant/raffinate pits area, the quarry, and vicinity properties. A second dose equivalent for a collective population was calculated for users of the August A. Busch Memorial Conservation Area. A third set of dose equivalent calculations was performed to meet NESHAPs requirements (see Section 6). Results of these estimates were then compared to applicable standards to evaluate the impact on members of the public and the environment.

Statistical analysis of the annual results indicated that although four perimeter low volume particulate sampling locations averaged greater than background in 1995, no concentrations greater than background were detected by high volume NESHAPs monitoring devices at critical receptor locations. Calculations using perimeter and off-site monitoring data determined the collective population dose equivalent to be less than 1 person-rem per year (0.01 person-Sv)

from all pathways combined. Since all off-site low volume air particulate samplers and radon gas detectors (other than the background station) are within a 13 km (8.1 mi) radius of the site, and all results measured within this radius are well below NESHAPs and DOE limits, incorporating a dose calculation for a population within 80 km (49.6 mi) of the site is unnecessary. However, the collective dose equivalent was calculated for specific target populations where complete exposure pathways were found to exist.

The scenarios and models used to evaluate these radiological exposures are conservative but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual using the methods described. Estimates of health risks are based on statistical data collected from large groups of people exposed to radiation under various circumstances; therefore, statistical models are not applicable to single individuals. Dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable but conservative scenario. This method is acceptable when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case at the WSSRAP. The scenarios and resulting estimated doses used in the calculations are outlined in Table 5-3. In addition, the percentage of the DOE guideline of 100 mrem (1.0 mSv) is provided.

The collective population dose equivalent estimate, provided in units of person-rem (person-Sv), is the product of the effective dose equivalent estimate at the exposure point and the number of persons exposed. Exposure points are locations where members of the public are potentially exposed to airborne radioactive particulate concentrations, radon gas concentrations, external gamma radiation, or radionuclide concentrations in water or food at above-background levels. The effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, food, and external gamma pathways at a given exposure point and applying standard breathing rates and dose equivalent conversion factors. These concentrations and reasonable exposure scenarios are used to estimate the amount of radioactivity ingested or inhaled and the amount of external gamma radiation received by the potentially exposed population.

All ingestion and inhalation (internal radiation exposure routes) calculations were performed using the methodology described in *International Commission on Radiation Protection* (ICRP) Reports 26 and 30 (Ref. 26 and 27) for a 50-year committed effective dose equivalent.

Fifty-year committed effective dose equivalent (CEDE) conversion factors were obtained from the EPA *Federal Guidance Report No. 11* (Ref. 28).

5.4 Dose Equivalent Estimates

Dose equivalent estimates for the exposure scenarios are presented in Table 5-3 and were calculated using 1995 monitoring data. Calculations for dose scenarios are provided in Appendix B. Dose equivalent estimates are far below the standards set by the DOE for annual public exposure and EPA NESHAPs limits.

The total effective dose equivalents (TEDEs) for a hypothetical maximally exposed individual near the chemical plant/raffinate pits, quarry, and vicinity properties are 0.041 mrem (4.1E-4 mSv), 0.12 mrem (0.0012 mSv), and 0.0079 mrem (7.9E-5 mSv), respectively. These values represent less than 1% of the DOE standard of 100 mrem (1 mSv) above background for all exposure pathways. In comparison, the annual average exposure to natural background radiation in the area of the site results in a TEDE of approximately 300 mrem (3 mSv). The collective population dose equivalent is 0.043 person-rem (4.3E-4 person-Sv) for recreational users of the Busch Memorial Conservation Area.

5.4.1 Radiation Dose Equivalent From the Chemical Plant/Raffinate Pits to a Hypothetical Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical individual assumed to frequent the perimeter of the chemical plant/raffinate pits and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent due to the applicable pathway of airborne radioactive particulate inhalation assume a realistic residence time that is less than 100%. Use of the Weldon Spring Training Area by military personnel is considered in the assessment of the exposure of a maximally exposed individual to airborne releases of radionuclides from the chemical plant/raffinate pits area. Low volume radioactive airborne particulate sampler AP-3004, near the Weldon Spring Training Area, indicated above background concentrations of radionuclides; however, critical receptor location AP-4008, on the Army property, was not statistically greater than background for either high or low volume measurements.

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INHALATION/ INGESTION RATE	CONCENTRATION	ESTIMATED EFFECTIVE DOSE EQUIVALENT (MREM)	PERCENT OF DOE GUIDANCE LIMIT
WSCP/WSRP Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	Walking near WSCP perimeter	Air	10 hours	16 mrem/yr	N/A	0.018	0.018%
	Airborne(A)	Walking near WSCP perimeter	Air	10 hours	1.25 m^3/hour[a]	1.7E-16 μCi/ml	5.5E-4	0.0006%
	Airborne(B)	Walking near WSCP perimeter	Air	10 hours	1.25 m^3/hour[a]	Rn-222 0.3 pCi/l	0.022	0.022%
WSQ Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	Walking near WSQ perimeter	Air	5 hours	15 mrem/yr	N/A	0.0086	0.0086%
	Airborne(A)	Walking near WSQ perimeter	Air	5 hours	1.25 m^3/hour[a]	7.1E-16 μCi/ml	1.2E-3	0.0012%
	Airborne(B)	Walking near WSQ perimeter	Air	5 hours	1.25 m^3/hour[a]	Rn-220 0.7 pCi/l	0.108	0.108%

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INHALATION/ INGESTION RATE	CONCENTRATION	ESTIMATED EFFECTIVE DOSE EQUIVALENT (MREM)	PERCENT OF DOE GUIDANCE LIMIT
WSVP Hypothetical Individual	Liquid(B)	Consumption of fish from slough	Fish	N/A	6.5 g/day	0.005 pCi/g	0.0034	0.0034%
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(A)	Fishing at slough	Air	62.5 hours	0.96 m^3/hour[a]	2.9E-16 μCi/ml	0.0045	0.0045%
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 5-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

EXPOSURE SCENARIO	PATHWAY	ACTIVITY	MEDIA	EXPOSURE DURATION	EXPOSURE/ INHALATION/ INGESTION RATE	CONCENTRATION	COLLECTIVE POPULATION DOSE EQUIVALENT (person-rem)	PERCENT OF DOE GUIDANCE LIMIT
Collective Population	Liquid(B)	Fishing at Busch Lake 36 (population = 5,985)	Fish	N/A	200 g/person	0.009 pCi/g	0.041	N/A
	Liquid(C)	Swimming at Busch Lake 36 (population = 5,985)	Sediments	0.285 hr/person	200 mg/day	91.1 pCi/g	0.0004	N/A
			Water	0.285 hr/person	0.05 liters/hour	67.5 pCi/l	0.0016	N/A
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A Indicates measurements for radioactivity for a media/exposure pathway at background levels.
WSCP Weldon Spring Chemical Plant
WSRP Weldon Spring raffinate pits
WSQ Weldon Spring Quarry
WSVP Weldon Spring vicinity properties
Multiply by 0.037 to convert pCi to Bq
Multiply by 0.01 to convert mrem to mSv
Multiply by 0.01 to convert person-rem to person-Sv
(a) A breathing rate of 0.96 m^3/hour is used for an individual engaged in light activity, while 1.25 m^3/hour is for an individual engaged in strenuous activity (Ref. 25).

Although the low and high volume samplers at the Weldon Spring Training Area indicated no above-background concentrations of radionuclides from the WSSRAP, a dose estimate was calculated based on the average net concentration above background levels, as measured by the low volume sampler at Station AP-3004. The dose estimate performed assumes the primary contaminant is Th-230.

The exposure scenario assumptions are as follows:

- Inhalation dose occurs to maximally exposed individual while walking near the Weldon Spring Chemical Plant perimeter for a total of 10 hours per year.
- Net airborne particulate concentration of 1.7E-16 μCi/ml (6.3E-12 Bq/ml) measured at AP-3004 at the southwestern boundary of the chemical plant.
- Net radon concentration of 0.3 pCi/l (0.01 Bq/l), measured at RD-3003 at the southwestern boundary of the chemical plant.
- The effective dose equivalent conversion factor was 1.25 rem/WLM (12.5 mSv/WLM).

Based on the exposure scenario and assumptions described above, a maximally exposed individual who frequented the Weldon Spring Training Area received a total effective dose equivalent of 0.041 mrem (4.1E-4 mSv) from external exposure and inhalation of airborne particulates and radon.

5.4.2 Radiation Dose From the Weldon Spring Quarry to a Hypothetical Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical individual assumed to frequent the perimeter of the Weldon Spring Quarry. The only private residence adjacent to the quarry site is monitored as a critical receptor, and all 1995 monitoring results indicated no above background exposure pathways. Therefore, all calculations of dose equivalent due to the applicable pathways of airborne radioactive particulate inhalation (Airborne A), radon progeny inhalation (Airborne B), and direct external gamma exposure assume a realistic residence time

of 5 hours/year, based on a hypothetical individual who hikes along the southeastern boundary of the quarry. The 5 hours/year assumption represents twice the value estimated for hikers at the Weldon Spring Conservation Area (Ref. 30).

Exposure scenario assumptions particular to this dose calculation are as follows:

- No contribution from pathways Liquid(B) or Liquid(C) in Table 5-1 was assumed because access to the quarry was controlled by 24-hour security and a 2.4 m (8 ft) chain link fence topped with barbed wire. Fishing, swimming, and drinking water from the quarry pond were not considered to be realistic exposure pathways.

- The individual hiked around the southeastern perimeter of the quarry 5 hours/year.

- The net gamma radiation exposure (measured at TD-1003) was 15 mrem/year (0.15 mSv/year).

- The highest estimated annual average concentration of Rn-220 gas, at RD-1002, was 0.7 pCi/l (0.03 Bq/m^3) above the normal background concentration of 0.2 pCi/l (0.007 Bq/m^3).

- The equilibrium ratio between Rn-220 gas and its progeny was 10%.

- The effective dose equivalent conversion factor was 0.42 rem/WLM (4.2 mSv/WLM) for Rn-220 (Ref. 31).

The total effective dose equivalent to the hypothetical maximally exposed individual at the quarry was 0.12 mrem (0.0012 mSv) from inhalation of radon progeny, inhalation of airborne particulates, and direct gamma exposure.

5.4.3 Radiation Dose From Vicinity Properties to a Hypothetical Maximally Exposed Individual

This section discusses the estimated effective dose equivalent to a hypothetical individual assumed to frequent the Femme Osage Slough, south of the quarry. This scenario provides a

conservative but plausible exposure assessment. No private residences are adjacent to the slough (it is situated on land currently managed by the Missouri Department of Conservation (MDC) as part of the Weldon Spring Conservation Area); therefore, all calculations of dose equivalent due to the applicable pathways of fish and ingestion (Liquid B) assume a realistic residence time of 62.5 hours/year. This scenario uses the applicable exposure pathways listed in Table 5-1 and is based on a hypothetical individual who fished at the Femme Osage Slough.

Exposure scenario assumptions particular to this dose calculation include the following:

- An annual average radioactive air particulate concentration of 2.9E-16 μCi/ml (1.1E-11 Bq/ml) above background, measured by the low volume sampler at station AP-1010 (see Figure 5-2), was used in the dose estimate.

- No contribution to the estimated dose was included from radon progeny concentrations associated with the Airborne (B) pathway, because the slough is contaminated only with uranium and is covered with water. Consequently, above-background concentrations of radon are not expected at this location.

- The average total uranium concentration in fish samples taken from the Femme Osage Slough was 0.005 pCi/g (1.9E-4 Bq/g) (see Section 9.3.1.1).

- The fresh water fish consumption rate was 6.5 g/day (0.23 oz/day) (Ref. 32).

- No contribution from pathway Liquid (C) was included because the stagnant water conditions made it unlikely that the slough would be used for recreational swimming.

The total effective dose equivalent to the maximally exposed individual at the vicinity properties from consumption of fish tissue and inhalation of radioactive air particulates at the Femme Osage Slough as discussed above was 0.0079 mrem (7.9E-5 mSv).

5.4.4 Collective Population Dose

This section discusses the estimated collective TEDE to the populations assumed to frequent the Busch Memorial Conservation Area. This scenario provides a conservative but

plausible exposure assessment. Results of NESHAPs critical receptor measurements at locations where members of the public are likely to frequent indicated radioactive air particulate concentrations that were indistinguishable from background levels. However, the ingestion pathways Liquid (B) and Liquid (C) were considered plausible. Hence, visitors to the Busch Memorial Conservation Area were considered in estimating the collective population dose equivalent due to remediation activities at the WSSRAP. Dose contributions from air particulates, radon gas and gamma radiation at this location were not considered in the collective population dose estimates because they were indistinguishable from background levels during 1995.

The scenario used for the Busch Memorial Conservation Area is based on recreational use for fishing and boating activities. Exposure scenario assumptions particular to this dose calculation are as follows:

- The MDC estimates that approximately 160,000 persons per year use the Busch Memorial Conservation Area, which is adjacent to the chemical plant and raffinate pits area, while another 5,895 persons participate in recreational boating activities. Busch Lakes 34, 35, and 36 receive runoff from the chemical plant and raffinate pits site, and all three lakes are utilized for fishing and boating purposes. Therefore, a population of 165,895 persons was assumed to have potential for exposure through ingestion of fish, water, and sediment from these lakes.

- If each fish caught is consumed by a different person, the affected population would be 80,000 persons.

- The highest average total uranium concentration in the fish collected from Lakes 34, 35, and 36 was 0.009 pCi/g (3.3E-4 Bq/g) (Section 8.3.1.1).

- The average time spent at the Busch Conservation Area per boating trip was approximately 5.7 hours.

- The average time per fishing trip was 2.5 hours.

- Each of 5,895 visitors made only one visit to the area and spent 5% of the time swimming.

- Maximum water concentrations were 67.5 pCi/l (2.5 Bq/l) and sediment concentrations were 91.1 pCi/g (3.4 Bq/g).

- No contribution from radon and its progeny was included in the Busch Memorial Conservation Area dose estimates. Results from the measurements near the lakes indicated that there was no reason to suspect at the 95% confidence level that concentrations were greater than background levels.

The estimated population dose equivalent for the Busch lakes scenario was 0.043 person-rem (4.3E-4 person-Sv).

5.5 Highlights

- The largest TEDE to a maximally exposed individual from all pathways combined was 0.12 mrem (0.0012 mSv), estimated for an individual who hikes around the quarry perimeter 5 hours per year. This value represents 0.12% of the DOE guideline of 100 mrem (1 mSv) above background levels.

- The collective population dose equivalent was estimated to be 0.043 person-rem (0.00043 person-Sv).

6 NESHAPS PROGRAM

This section provides information on 1995 annual atmospheric emissions of radionuclides, in accordance with the requirements of 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*. Evaluations presented here include airborne emissions data and dose assessment/compliance information related to sources of radioactive particulate emissions at the Weldon Spring Site Remedial Action Project (WSSRAP). This section is prepared in fulfillment of the required annual National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring report for the Weldon Spring site.

6.1 Facility Information

6.1.1 Site Description

Specific information about the Weldon Spring site can be found in Section 1 of this report.

6.1.2 Source Description

The Weldon Spring site is being remediated in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and the *National Environmental Policy Act* (NEPA). It no longer operates as a uranium and thorium processing plant and has been in mothball status since about 1966. Therefore, radionuclides are no longer emitted from the original uranium processing plant sources (i.e., stacks, vents, or pipes) described in 40 CFR 61, Subpart H.

Most airborne emissions of radionuclides at the Weldon Spring site result from wind dispersion of surface soils or dust and dirt from building debris and fugitive dust generated during remedial actions. The two on-site water treatment plants and the chemical stabilization/solidification (CSS) pilot facility, however, constitute potential emission points ("point sources").

6.2 Air Emission Data

Most airborne emissions of radionuclides at the Weldon Spring site result from wind dispersion of surface soils and fugitive dust generated during remedial actions. Modeling such emission sources is not practical because of the inability to adequately characterize the emission inventory. The amount of entrainment can be estimated from fugitive dust emission factors developed by the U.S. Environmental Protection Agency (EPA) for various materials handling activities, but it is generally recognized that those estimates contain gross uncertainties. Measurement of the entrainment and emissions inventory is also extremely difficult and results are uncertain at best, because the emissions are highly variable over both time and location. Accurate measurements of area or volumetric fugitive emissions can only be made with complete knowledge of the micro-meteorology in and around the source and the use of many (usually greater than 10) measurement locations. Therefore, modeling of downwind dispersion and subsequent dose calculations using either assumed or measured emission rates leads to extremely uncertain results.

After evaluating the methods of assessing effective dose equivalents from radionuclide emissions from the Weldon Spring site, it was determined that monitoring air concentrations at critical receptors was the most accurate means of assessing effective dose equivalents to maximally exposed individuals. This alternative approach has been approved by EPA Region VII.

6.2.1 Point Sources

Table 6-1 briefly describes the two water treatment plants and CSS pilot facility and lists their nearest receptor locations. Because critical receptor monitoring is performed at the WSSRAP, additional effluent monitoring under the requirements of 40 CFR 61 Subpart H and DOE Order 5400.5 is not required. In addition to critical receptor monitoring, engineering calculations have been performed to assess releases from the quarry and chemical plant water treatment plants and resulting dose equivalents to members of the public. These results indicate a dose equivalent of less than 0.1 mrem (0.001 mSv) at the nearest on-site receptor location, the WSSRAP administration building.

TABLE 6-1 WSSRAP Point Sources

POINT SOURCE I.D.	EFFLUENT CONTROL		NEAREST RECEPTOR	
	DESCRIPTION	EFFICIENCY	DESCRIPTION	DISTANCE
Site Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP	Administration Building	400 m
Quarry Water Treatment Plant	High Efficiency Air Particulate (HEPA) Filtered	99.97% for 0.3 micron DOP	Residence	700 m
CSS Pilot Facility	High efficiency air particulate (HEPA) filtered	99.97% for 0.3 micron DOP	Administration Building	600 m

6.2.2 Group Sources

The WSSRAP has not defined any grouped sources.

6.2.3 Non-Point Sources

The WSSRAP primary sources for emissions are diffuse sources that at the most basic level consist of two areas, a chemical plant area and a quarry area. Due to the many different and constantly changing activities within these areas, the WSSRAP has chosen to monitor airborne concentrations at nearby critical receptor locations to demonstrate compliance with the NESHAPs standard.

The quarry diffuse source is a 3.6 ha (9-acre) limestone quarry located approximately 6.4 km (4 mi) south-southwest of the chemical plant area. The quarry is essentially in a closed basin; surface water within the rim flows to the quarry floor and into a pond that covers approximately 0.2 ha (0.5 acre). The quarry was used as a disposal area for dinitrotoluene (DNT) and trinitrotoluene (TNT) process wastes; uranium, radium, and thorium residues; the associated daughter products from on-site and off-site processing of uranium and thorium; and building rubble and soils from the demolition of a uranium processing facility in St. Louis, Missouri. Airborne emissions from the quarry result from the wind blown resuspension of

radioactive particulates from quarry soils and resuspension of radioactive particulates due to remediation activities at the quarry, such as the operation of heavy equipment and the excavation of soils. Bulk waste removal was essentially complete by the end of 1995, and residual waste characterization is now in progress.

The Weldon Spring Chemical Plant and raffinate pits diffuse source encompasses 87 ha (217 acres) on which approximately 45 building foundations, four raffinate pits, the temporary storage area (TSA), and the material staging area (MSA) are located. Airborne emissions from the chemical plant result from windblown resuspension of radioactive particulates from site soils and chemical plant building material/debris, and resuspension of radioactive particulates from site operations such as bulk waste placement and soil excavation. Because the WSSRAP does not attempt to determine emissions from specific diffuse sources within the chemical plant and quarry areas, it is impossible to provide a realistic estimate of total emissions. However, to provide the required information, estimates are based on a simple box model. These estimates are provided in Section 5.2 of this report.

6.3 Dose Assessment

Due to the uncertainties associated with modeling airborne radionuclide emissions resulting from radioactive sources at the Weldon Spring site, the WSSRAP has chosen a more reliable method of critical receptor monitoring. Critical receptor locations are places where members of the public abide or reside and have a potential to encounter off-site concentrations of radionuclides other than radon during WSSRAP remediation activities. The critical receptor monitoring methodology is described in the WSSRAP *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by EPA Region VII.

6.3.1 Sampling Procedure

As mentioned in Section 3.2.1.1 of this report, six designated critical receptor locations surrounding the Weldon Spring site have been selected in order to achieve compliance with NESHAPs requirements. The six locations were selected based on their proximity to the site (less than 1 km [0.62 mi]) and the probability that members of the public would spend at least 8 hours per day near them. The six critical receptor locations and the background monitoring

location are shown in Figure 6-1 and are described in Table 6-2. They include: the common boundary of the Weldon Spring Chemical Plant and the Missouri Highway Maintenance Facility (AP-2001); the WSSRAP administration building (AP-2005); Francis Howell High School (AP-4006); the August A. Busch Memorial Conservation Area (AP-4007); the Weldon Spring Training Area on the Department of the Army property (AP-4008); and 150 m (0.1 mi) from the residence nearest to the quarry (AP-4011). Technically, the WSSRAP administration building is considered an on-site receptor rather than a critical receptor because its occupants are not members of the general public, and the area is under DOE control. However, for reporting purposes, it is referred to as a "critical receptor." Daniel Boone Elementary School is the designated background monitoring location (AP-4012).

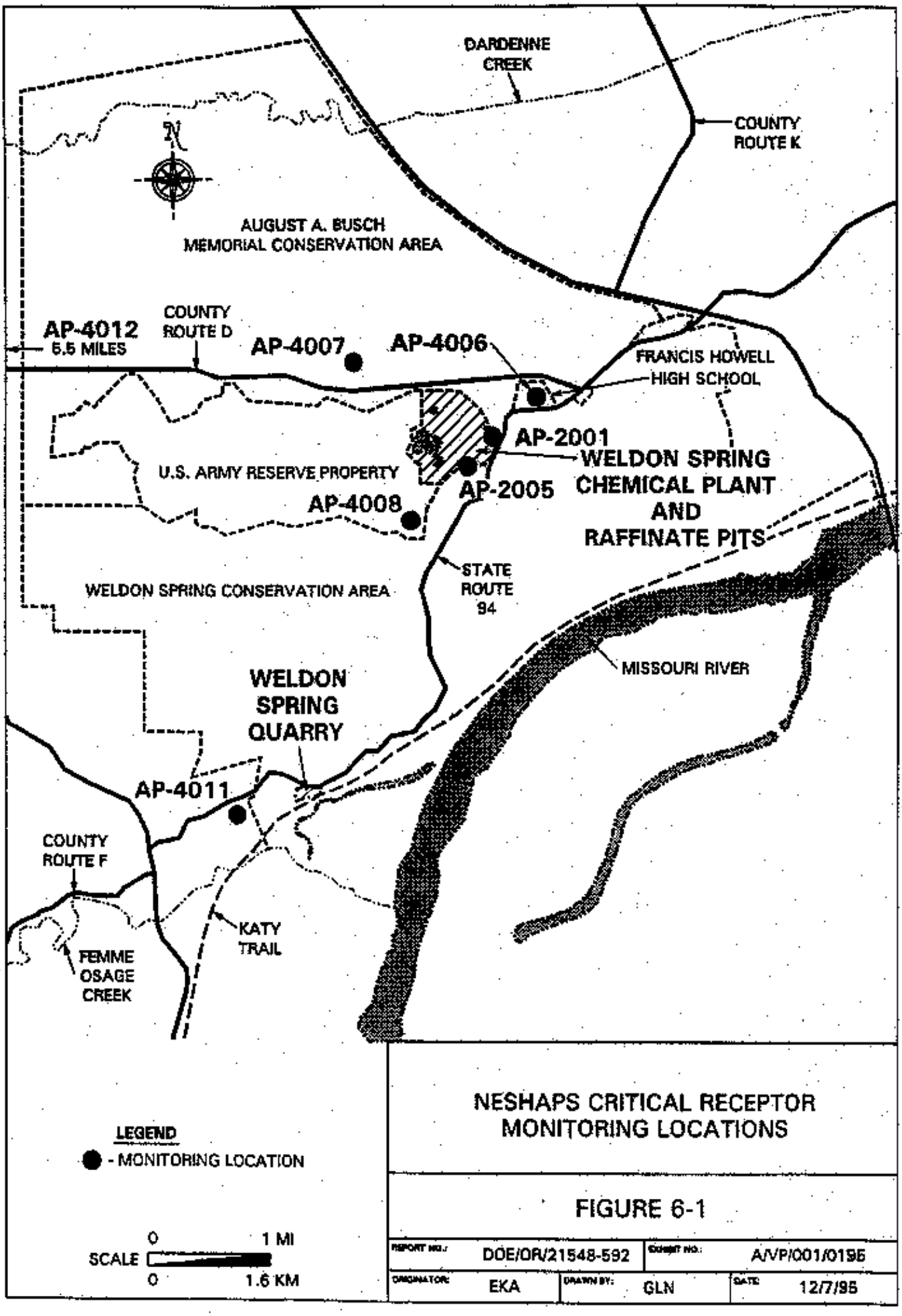
Each critical receptor location includes a low volume air sampler (~40 lpm) and a high volume air sampler (~950 lpm). Low volume samples are collected on mixed cellulose ester membrane filters approximately 1.5 m (5 ft) above the ground, and are exchanged on a weekly basis. High volume samples are collected on large glass fiber or membrane filters approximately 1.2 m (4 ft) above the ground, which are also exchanged weekly. It is the high volume sampling results that are used to demonstrate NESHAPs compliance at the WSSRAP.

At the beginning of each calendar quarter, the high volume filters collected over the previous quarter are composited to form seven distinct samples, one for each critical receptor location and background station. The high volume samples are analyzed for isotopic thorium, total uranium, Ra-226, and Ra-228. For reporting purposes, the background concentrations are subtracted from each sample concentration. If background concentrations are greater than the concentration of the critical receptor sample, a negative value is reported.

6.3.2 Compliance Assessment

Based on the results of the high volume samples, a realistic exposure scenario and dose estimate was developed for each of the six critical receptor locations. The assumptions made for the dose estimates include:

- Breathing rate of 1.25 m^3/h (44.1 ft^3/h);



NESHAPS CRITICAL RECEPTOR MONITORING LOCATIONS

FIGURE 6-1

REPORT NO.:	DOE/OR/21548-592	SUBJECT NO.:	A/VP/001/0195
ORIGINATOR:	EKA	DRAWN BY:	GLN
DATE:	12/7/95		

TABLE 6-2 Exposure Scenarios and NESHAPs Dose Estimates for 1995

CRITICAL RECEPTOR	SAMPLE ID	TOTAL INDIVIDUALS	EXPOSURE DURATION	ESTIMATED DOSE EQUIVALENT (mrem)
Missouri Highway Maintenance Facility	AP-2001	9	2,000 hr/yr	0.01 ± 0.24
WSSRAP administration building	AP-2005	290	2,500 hr/yr	0.08 ± 0.32
Francis Howell High School - Assessment 1	AP-4006	2,700	2,250 hr/yr	0.05 ± 0.31
Francis Howell High School - Assessment 2	AP-4006	1[a]	8,760 hr/yr	0.18 ± 1.2
Busch Memorial Conservation Area	AP-4007	25	2,500 hr/yr	0.06 ± 0.27
Weldon Spring Training Area	AP-4008	1[b]	2,000 hr/yr	0.07 ± 0.38
Nearest quarry residence	AP-4011	1[c]	8,760 hr/yr	0.41 ± 1.1

(a) One individual residing full-time on school properties.
(b) One employee working full-time on Army property.
(c) One individual living at residence.
Multiply by 0.01 to convert mrem to mSv
hr/yr Hours per year

- 50-year committed effective dose equivalent conversion factors provided in EPA Federal Guidance Report No. 11 (Ref. 28);

- Exposure duration listed in Table 6-2.

The dose calculations for each critical receptor are listed in Table 6-3. The maximum dose equivalent calculated for NESHAPs critical receptors was 0.41 ± 1.1 mrem (0.004 mSv) committed effective dose equivalent (CEDE) at AP-4011 for an individual residing at the residence nearest the quarry. All doses for critical receptor locations are less than 1 mrem (0.01 mSv) for the entire year, and are comparable to those calculated for 1994. These values are well below the NESHAPs limit of 10 mrem (0.10 mSv) total effective dose equivalent per year.

6.4 Additional Information

No unplanned releases to the atmosphere occurred in 1995.

Releases from the WSSRAP are primarily due to diffuse sources. The dose equivalent estimates listed in Table 6-3 are based on critical receptor monitoring, and therefore estimate the dose due to both point source and diffuse source emissions.

Data quality review of precision and accuracy for the NESHAPs high volume samples established in the *Plan for Monitoring Radionuclides Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21) indicated that the data quality objectives (DQOs) for precision were met, however; the DQOs for accuracy were not met for the first and fourth quarters of 1995. Accuracy tests indicated failure of the Th-230 spiked samples to meet the known value objective of $\pm 50\%$ for 85% of the samples. The uranium spiked samples met this objective. Failure of the Th-230 spikes accuracy is believed to be caused by spike preparation problems rather than by laboratory analysis problems.

A new Th-230 spike was prepared and preserved with nitric acid for the second quarter 1995. This resulted in 100% of the Th-230 spiked filters meeting the DQO for accuracy. In the third quarter, 67% of the Th-230 spiked filters met the DQO for accuracy. In the fourth quarter, all Th-230 spiked filters failed the DQO for accuracy. This pattern of decreasing

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1995

AP-2001	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.43E-12 ± N/A	0.0001 ± N/A	7.39E-11 ± N/A	0.0044 ± N/A	1.81E-11 ± N/A	0.0011 ± N/A	1.75E-11 ± N/A	0.0011 ± N/A	0.0068 ± N/A
Ra-226	-2.4E-11 ± 2.38E-10	0 ± 0.0010	-6.6E-11 ± 1.23E-9	0 ± 0.0061	-4.1E-11 ± 4.07E-10	0 ± 0.0017	1.47E-11 ± 8.43E-11	0.0001 ± 0.0004	0.0001 ± 0.0065
Ra-228	-7.0E-11 ± 2.38E-10	0 ± 0.0030	-4.2E-10 ± 1.71E-9	0 ± 0.0039	-4.3E-10 ± 2.11E-9	0 ± 0.0048	9.68E-10 ± 1.71E-9	0.0022 ± 0.0039	0.0022 ± 0.0079
Th-228	-1.1E-11 ± 1.68E-10	0 ± 0.0275	-1.5E-12 ± 1.77E-10	0 ± 0.0290	1.94E-11 ± 1.39E-10	0.0032 ± 0.0228	-1.5E-12 ± 6.49E-11	0.0002 ± 0.0106	0.0034 ± 0.0472
Th-230	-3.2E-11 ± 1.92E-10	0 ± 0.0301	-3.8E-11 ± 2.00E-10	0 ± 0.0313	1.92E-12 ± 3.63E-10	0.0003 ± 0.0551	-3.3E-11 ± 2.44E-10	0 ± 0.0381	0.0003 ± 0.0798
Th-232	-9.6E-12 ± 1.68E-10	0 ± 0.1317	-1.8E-11 ± 1.59E-10	0 ± 0.1247	-4.1E-11 ± 1.53E-10	0 ± 0.1204	9.42E-13 ± 7.17E-11	0.0007 ± 0.0564	0.0007 ± 0.2248
EDE		0.0001 ± 0.1380		0.0044 ± 0.1319		0.0046 ± 0.1345		0.0043 ± 0.0690	0.0135 ± 0.2435
AP-2005	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.30E-10 ± N/A	0.0100 ± N/A	3.42E-11 ± N/A	0.0026 ± N/A	4.85E-11 ± N/A	0.0037 ± N/A	2.0E-10 ± N/A	0.0150 ± N/A	0.0313 ± N/A
Ra-226	-1.6E-11 ± 2.56E-10	0 ± 0.0002	-6.9E-11 ± 1.39E-9	0 ± 0.0071	-5.2E-12 ± 4.18E-10	0 ± 0.0022	5.86E-11 ± 1.02E-10	0.0003 ± 0.0005	0.0003 ± 0.0075
Ra-228	-2.7E-11 ± 1.3E-9	0 ± 0.0037	-3.8E-10 ± 1.59E-9	0 ± 0.0046	-2.9E-10 ± 2.66E-9	0 ± 0.0059	8.56E-10 ± 1.7E-9	0.0024 ± 0.0154	0.0024 ± 0.0175
Th-228	-1.2E-12 ± 1.99E-10	0 ± 0.0408	-1.2E-11 ± 1.67E-10	0 ± 0.0342	1.65E-11 ± 1.54E-10	0.0034 ± 0.0315	1.09E-11 ± 7.53E-11	0.0022 ± 0.0154	0.0056 ± 0.0637
Th-230	8.35E-12 ± 1.9E-10	0.0016 ± 0.0371	-3.6E-11 ± 1.71E-10	0 ± 0.0334	0 ± 3.68E-10	0 ± 0.0718	-3.0E-11 ± 2.64E-10	0 ± 0.0515	0.0016 ± 0.1015
Th-232	5.77E-12 ± 1.93E-10	0.0057 ± 0.1900	-1.9E-11 ± 1.51E-10	0 ± 0.1482	-4.1E-11 ± 1.62E-10	0 ± 0.1594	3.73E-11 ± 8.4E-11	0.0367 ± 0.0826	0.0427 ± 0.3004
EDE		0.0100 ± 0.1980		0.0026 ± 0.1559		0.0071 ± 0.1778		0.0566 ± 0.0985	0.0839 ± 0.3239

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1995 (Continued)

AP-4006	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-3.1E-12 ± N/A	0 ± N/A	1.17E-10 ± N/A	0.0079 ± N/A	1.83E 11 ± N/A	0.0012 ± N/A	2.2E-11 ± N/A	0.0015 ± N/A	0.0106 ± N/A
Ra-226	-2.4E-11 ± 2.43E-10	0 ± 0.0011	-6.6E-11 ± 8.76E-10	0 ± 0.0041	-2.6E-11 ± 4.63E-10	0 ± 0.0021	-5.2E-13 ± 9.48E-11	0 ± 0.0004	0 ± 0.0048
Ra-228	5.06E-11 ± 1.24E-9	0.0001 ± 0.0032	3.06E-11 ± 2.13E-9	0.0001 ± 0.0055	-6.2E-10 ± 2.2E-9	0 ± 0.0057	4.38E-10 ± 1.74E-9	0.0011 ± 0.0045	0.0013 ± 0.0097
Th-228	-1.0E-11 ± 2.01E-10	0 ± 0.0371	4.52E-12 ± 2.14E-10	0.0009 ± 0.3999	9.85E-12 ± 1.35E-10	0.0018 ± 0.0248	-2.2E-12 ± 6.83E-11	0 ± 0.0126	0.0026 ± 0.0610
Th-230	-3.2E-11 ± 1.96E-10	0 ± 0.0344	-3.8E-11 ± 2.02E-10	0 ± 0.0355	1.07E-11 ± 3.52E-10	0.0019 ± 0.0619	-3.3E-11 ± 2.61E-10	0 ± 0.0459	0.0019 ± 0.0916
Th-232	-3.4E-11 ± 1.89E-10	0 ± 0.1872	3.46E-11 ± 2.04E-10	0.0307 ± 0.1805	-4.1E-11 ± 1.47E-10	0 ± 0.1307	-8.2E-12 ± 7.48E-11	0 ± 0.0662	0.0307 ± 0.2864
EDE	0.0001 ± 0.1747		0.0385 ± 0.1883		0.0049 ± 0.1468		0.0026 ± 0.0817		0.0471 ± 0.3070
AP-4007	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Net Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.11E-11 ± N/A	0.0007 ± N/A	-2.5E-11 ± N/A	0 ± N/A	2.12E-10 ± N/A	0.0128 ± N/A	1.25E-10 ± N/A	0.0075 ± N/A	0.021 ± N/A
Ra 226	-1.8E-11 ± 2.58E-10	0 ± 0.0011	-6.6E-11 ± 8.89E-10	0 ± 0.0037	2.84E-11 ± 4.35E-10	0.0001 ± 0.0018	6.87E-12 ± 1.48E-10	0 ± 0.0006	0.0001 ± 0.0043
Ra-228	3.32E-10 ± 1.34E-9	0.0008 ± 0.0031	-5.4E-10 ± 1.84E-9	0 ± 0.0042	-5.7E-10 ± 2.22E-9	0 ± 0.0051	5.44E-10 ± 1.84E-9	0.0012 ± 0.0042	0.0020 ± 0.0842
Th-228	-8.3E-12 ± 1.99E-10	0 ± 0.0321	8.25E-13 ± 1.76E-10	0.0001 ± 0.0288	0 ± 1.78E-10	0 ± 0.0292	2.19E-11 ± 7.49E-11	0.0036 ± 0.0128	0.0037 ± 0.0535
Th-230	-3.2E-11 ± 2.14E-10	0 ± 0.0334	-3.2E-11 ± 1.81E-10	0 ± 0.0283	2.11E-12 ± 4.18E-10	0.0003 ± 0.0654	-3.3E-11 ± 2.58E-10	0 ± 0.0403	0.0003 ± 0.0884
Th-232	-1.2E-11 ± 1.87E-10	0 ± 0.1469	1.81E-11 ± 1.66E-10	0.0143 ± 0.1305	-3.4E-11 ± 1.67E-10	0 ± 0.1310	2.46E-11 ± 7.77E-11	0.0194 ± 0.0611	0.0337 ± 0.2439
EDE	0.0015 ± 0.1541		0.0144 ± 0.1367		0.0132 ± 0.1494		0.0317 ± 0.0743		0.0608 ± 0.2720

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1995 (Continued)

AP-4008	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	2.73E-12 ± N/A	0.0002 ± N/A	4.48E-11 ± N/A	0.0027 ± N/A	-8.1E-11 ± N/A	0 ± N/A	4.85E-11 ± N/A	0.0029 ± N/A	0.0058 ± N/A
Ra-226	5.13E-13 ± 2.52E-10	0 ± 0.0010	-6.6E-11 ± 1.07E-9	0 ± 0.0044	1.26E-11 ± 4.87E-10	0.0001 ± 0.0020	2.96E-12 ± 1.01E-10	0 ± 0.0004	0.0001 ± 0.0050
Ra-228	-1.1E-10 ± 1.28E-9	0 ± 0.0029	-3.9E-10 ± 1.85E-9	0 ± 0.0042	-9.8E-10 ± 2.12E-9	0 ± 0.0049	2.9E-10 ± 1.58E-9	0.0007 ± 0.0036	0.0007 ± 0.0079
Th-228	5.02E-12 ± 1.73E-10	0.0008 ± 0.0283	6.81E-12 ± 1.77E-10	0.0011 ± 0.0291	1.19E-11 ± 1.43E-10	0.0020 ± 0.0236	-6.0E-12 ± 6.47E-11	0 ± 0.0106	0.0039 ± 0.0481
Th-230	-3.2E-11 ± 1.93E-10	0 ± 0.0302	-3.2E-11 ± 1.71E-10	0 ± 0.2667	2.09E-10 ± 4.63E-10	0.0326 ± 0.0724	-3.3E-11 ± 2.57E-10	0 ± 0.0401	0.0326 ± 0.2809
Th-232	-6.8E-12 ± 1.65E-10	0 ± 0.1286	4.02E-11 ± 1.7E-10	0.0316 ± 0.1338	-4.1E-11 ± 1.91E-10	0 ± 0.1501	-1.9E-12 ± 7.23E-11	0 ± 0.0569	0.0316 ± 0.2459
EDE		0.0010 ± 0.1361		0.0354 ± 0.1387		0.0347 ± 0.1884		0.0036 ± 0.0705	0.0747 ± 0.3795
AP-4011	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-2.9E-11 ± N/A	0 ± N/A	-2.4E-11 ± N/A	0 ± N/A	5.63E-10 ± N/A	0.1486 ± N/A	-5.0E-11 ± N/A	0 ± N/A	0.1486 ± N/A
Ra-226	-1.1E-11 ± 2.44E-10	0 ± 0.0044	-2.9E-11 ± 1.06E-9	0 ± 0.0192	-3.5E-11 ± 4.42E-10	0 ± 0.0080	2.0E-12 ± 1.22E-10	0 ± 0.0022	0 ± 0.0214
Ra-228	8.83E-11 ± 1.29E-9	0.0009 ± 0.0129	-3.0E-10 ± 1.83E-9	0 ± 0.0183	-4.9E-10 ± 2.19E-9	0 ± 0.0220	6.04E-10 ± 1.7E-9	0.0061 ± 0.0171	0.0070 ± 0.0357
Th-228	6.06E-12 ± 1.99E-10	0.0043 ± 0.1430	9.88E-12 ± 1.74E-10	0.0071 ± 0.1251	0 ± 1.35E-10	0 ± 0.0967	2.26E-12 ± 7.01E-11	0.0016 ± 0.0503	0.0130 ± 0.2190
Th-230	1.12E-10 ± 2.11E-10	0.0768 ± 0.1443	-3.8E-11 ± 1.82E-10	0 ± 0.1248	9.85E-11 ± 3.81E-10	0.0674 ± 0.2609	-3.2E-11 ± 2.55E-10	0 ± 0.1747	0.1442 ± 0.3674
Th-232	-1.1E-11 ± 1.89E-10	0 ± 0.8526	1.33E-11 ± 1.60E-10	0.0460 ± 0.5500	-1.7E-11 ± 1.63E-10	0 ± 0.5283	1.39E-11 ± 7.73E-11	0.0479 ± 0.2665	0.0939 ± 1.0395
EDE		0.0820 ± 0.6837		0.0531 ± 0.5783		0.2160 ± 0.5975		0.0556 ± 0.3231	0.4067 ± 1.1239

TABLE 6-3 NESHAPs Isotopic Air Monitoring Results With Effective Dose Equivalent Contributions, 1995 (Continued)

AP-4012	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Radionuclide	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)
Total U	1.54E-10 ± N/A	2.13E-10 ± N/A	1.71E 10 ± N/A	2.58E-10 ± N/A	--
Ra-226	2.4E-11 ± 1.66E-10	6.84E-11 ± 8.03E-10	7.4E-11 ± 3.08E-10	2.09E-11 ± 8.71E-11	--
Ra-228	2.88E-10 ± 8.02E-10	9.87E-10 ± 1.36E-9	1.24E-9 ± 1.52E-9	3.01E-10 ± 1.08E-9	--
Th-228	1.82E-11 ± 1.35E-10	1.15E-11 ± 1.33E-10	0 ± 1.0E-10	2.09E-11 ± 4.76E-11	--
Th-230	3.2E-11 ± 1.39E-10	3.75E-11 ± 1.39E-10	0 ± 2.47E-10	3.26E-11 ± 1.88E-10	--
Th-232	4.99E-11 ± 1.3E-10	1.76E-11 ± 1.22E-10	4.07E-11 ± 1.05E-10	2.47E-11 ± 5.04E-11	--

N/A Not available
-- Background annual dose not calculated
EDE Effective Dose Equivalent
Multiply by 0.01 to convert mrem to mSv.
Multiply by 37,000 to convert $\mu Ci/m^3$ to Bq/m^3.

accuracy, as time progresses after spike preparation, was also present in 1994. This indicates that the Th-230 in solution is gradually reduced over time. Therefore, the laboratory analyses may have been accurate. In addition, the laboratory prepared and analyzed Th-230 matrix spikes in house that indicated exceptable recoveries.

Starting in the first quarter of 1996, a new Th-230 spike solution will be prepared and used to spike one sample. The old spike will be used for another sample. Based on the analytical results of the newly prepared spike sample, a new spike solution will be prepared and used each quarter. This should allow the accuracy DQOs for Th-230 spike samples to be met.

6.5 Supplemental Information

Although not required by 40 CFR 61, this supplemental information is provided to assist the DOE in guidance development and for future interactions with the U.S. Environmental Protection Agency (EPA). Information includes the following: collective population dose equivalent due to airborne releases of radionuclides; status of compliance with 40 CFR 61 Subparts Q and T; details of non-storage radon emissions; a discussion of radionuclide emission points; and the status of the site quality assurance program for radionuclide emissions measurements.

6.5.1 Collective Population Dose Equivalent

The total 1995 collective population dose equivalent was 0.043 person-rem (4.3E-4 person-Sv). These estimates were calculated for users of the August A. Busch Memorial Conservation Area. The approximations were based only on ingestion of fish, water, and sediment while fishing and swimming. The NESHAPs monitoring results at the conservation headquarters building (Station AP-4007) indicated no above background concentrations of radionuclides. Station AP-4007 is shown in Figure 4-3.

6.5.2 Subparts Q and T of 40 CFR 61

The regulations contained in Subpart Q pertain to Rn-222 emissions from radium-containing storage or disposal facilities. Since the TSA was not yet completed in 1995,

Subpart Q did not apply. However, radon flux measurements at the TSA, as required by Subpart Q, are scheduled for 1996.

The regulations contained in 40 CFR 61 Subpart T apply only to sites that are "...listed in, or designated by, the Secretary of Energy under Title I of the *Uranium Mill Tailings Control Act of 1978* or regulated under Title II of the *Uranium Mill Tailings Control Act of 1978.*" Subpart T does not apply to the Weldon Spring site since it does not fall into the applicable categories.

6.5.3 Radon Emissions from WSSRAP Non-Storage Sources

6.5.3.1 Rn-220 Emissions. The Weldon Spring Quarry was used for disposal of a variety of radiologically and chemically contaminated wastes from the early 1940s to 1969. In 1995, transfer of quarry bulk waste to the temporary storage area (TSA) was virtually complete. Included in the radiologically contaminated waste disposal inventory is at least 800 cu yd (612 m^3) of Th-232 residues received from Cincinnati, Ohio in 1959 and 1966, and an unknown quantity of Th-232 contaminated residues, rubble, and equipment received since the shutdown of the chemical plant in 1966. Radiological characterizations of the quarry wastes were performed in 1984 and 1985. Ra-228 concentrations detected in the quarry wastes during characterization activities ranged from 1.0 pCi/g (0.037 Bq/g) to 2,200 pCi/g (81.4 Bq/g). Additional information about Th-232 wastes is contained in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 2).

To estimate the airborne Rn-220 emissions from the quarry during 1995, the above background modified alpha-track radon detector results were incorporated into a box model. The box model approach provides conservative results and is used in place of Gaussian dispersion modeling, which is generally inappropriate for estimates to close-in receptors. The estimated off-site Rn-220 release from the quarry was 3.3 Ci (1.2E-11 Bq). This corresponds to a committed effective dose equivalent to the hypothetical maximally exposed individual of 0.108 mrem (1.1E-3 mSv). Calculations and assumptions are provided in Appendix B.

Other potential Rn-220 sources are the TSA, which is currently storing quarry bulk wastes, and the four raffinate pits used for the storage of wastes from past uranium refinery operations. The chemical plant perimeter is monitored for radon gas at 12 locations using alpha

track radon monitors. These monitors are sensitive to all isotopes of radon. Statistical analysis at the 95% confidence level of the alpha track detector results indicated that perimeter Rn-220 concentrations during 1995 were not distinguishable from background levels.

6.5.3.2 Rn-222 Emissions. As stated in Section 6.5.3.1, the quarry was used for disposal of a variety of radiologically and chemically contaminated wastes from the early 1940s to 1969. In 1995 the quarry was a non-storage source of Rn-222. Virtually all the quarry bulk wastes are now in temporary storage at the TSA. Included in the waste disposal inventory is demolition rubble from the Destrehan Street feed materials plant in St. Louis, Missouri. The waste contained less than 1 Ci (3.7E10 Bq) of Ra-226 and covered approximately 0.40 ha (1 acre) of the quarry floor to a depth of about 9.1 m (30 ft). Also, several buildings at the chemical plant were decontaminated and approximately 4,200 m^3 (5,500 cu yd) of waste materials were dumped in the quarry. The wastes contained uranium and its progeny and were placed on the quarry floor. The extent of the radiological contamination of this material is unknown. Radiological characterizations of the above material were performed in 1984 and 1985. Ra-226 concentrations detected in the waste during characterization ranged from 0.2 pCi/g (0.007 Bq/g) to 2,780 pCi/g (103 Bq/g). Additional information about Ra-226 waste removed from the quarry is contained in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 2).

The other non-storage source of Rn-222 during 1995 was the four raffinate pits that were used for the storage of waste resulting from past uranium refinery operations. As in the technique used for Rn-220 (see previous section), the airborne Rn-222 emissions from the chemical plant during 1995 were estimated by incorporating the above background alpha track radon detector results into a box model. The estimated off-site Rn-222 release from the chemical plant was 15 Ci (5.6E-11 Bq). This corresponds to a committed effective dose equivalent to the hypothetical maximally exposed individual of 0.022 mrem (2.2E-4 mSv). Calculations and assumptions are provided in Appendix B.

6.5.4 Effluent Monitoring Requirements

The site water treatment plant and the quarry water treatment plant were in operation during 1995 and were potential point sources of radioactive airborne particulates. The WSSRAP has developed a plan to continuously monitor air concentrations of radioactive particulates at

designated critical receptor locations resulting from remedial activities, in accordance with 40 CFR 61.93, Paragraph (b)(5). This approach is contained in the report *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by EPA Region VII. The report includes a discussion of the WSSRAP quality assurance program for measurement of radionuclide emissions from the Weldon Spring site. This program conforms to the requirements of 40 CFR 61, Appendix B, Method 114, and ensures that emission measurements are representative and are of known precision and accuracy. Data quality objectives outlined by the quality assurance program are also discussed in Section 6.4.

7 SURFACE WATER PROTECTION

7.1 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) includes monitoring discharge points permitted under the National Pollutant Discharge Elimination System (NPDES) program and monitoring streams, ponds, and lakes under the surface water monitoring program.

The effluent, or NPDES, monitoring program at the Weldon Spring site establishes sampling requirements for discharge points (outfalls) at both the chemical plant and the quarry. The goals of this program are to maintain compliance with the NPDES permit requirements and to characterize water released from the site to protect the environment and the health of downstream water users. The Project Management Contractor (PMC) uses the water data to develop strategies to minimize the discharge of water borne contaminants from the site in accordance with the WSSRAP policy that all surface water be closely monitored and treated, as necessary, to meet Federal and State requirements.

In addition, the surface water monitoring program monitors off-site water bodies for any existing contamination and any changes in contamination levels. The data generated from this monitoring are used in conjunction with the NPDES monitoring to measure the success of the project's goal to clean up the site with no increase in contaminant discharge or degradation of the off-site water bodies.

7.2 Applicable Standards

The WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Effluent discharges from the site for 1995 were authorized by four NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be sampled under each permit. Each parameter is assigned either effluent limits or a "monitoring only" status, which means the concentrations are reported but not limited by the permit. Sampling frequencies and reporting requirements for the two major permits, MO-0107701 and MO-0108987, are summarized in Tables 7-1 and 7-2, respectively. These permits were reissued

TABLE 7-1 Weldon Spring Chemical Plant Storm and Sanitary Water (NPDES Permit MO-0107701) Monitoring Requirements

PARAMETER	LOCATION	
	NP-0002, NP-0003[e], NP-0005, NP-0010	NP-0006
Sampling Frequency	once/month	once/quarter
Flow	GPD (monitor only)	GPD (monitor only)[a]
Settleable Solids	1.0 ml/l/hr	---
TSS	mg/l (monitor only)[b]	15 / 20 mg/l[c]
Nitrate and Nitrite as N	mg/l (monitor only)	---
Uranium, total	mg/l (monitor only)*	---
Gross α	pCi/l (monitor only)	---
pH	6 - 9 standard units	6 - 9 standard units
Fecal coliform	---	400/1000 colonies/ 100 ml[d]
BOD	---	10/15 mg/l[c]

NOTE: Refer to Figure 7-1 for NPDES monitoring locations.

* Permit requires reporting in both mg/l and pCi/l and notification of MDNR if monthly average exceeds 2 mg/l or daily maximum exceeds 4 mg/l.
(a) Frequency is once/month.
(b) Limit is 50 mg/l if erosion control is not designed for a 1 in 10 year, 24-hour storm.
(c) Monthly average and weekly average changed to 30/45 mg/l on August 4, 1995.
(d) Monthly average/daily maximum.
(e) NPDES permit MO-0107701 was revised on August 4, 1995 to include sampling of creosote constituents, Cu and Zn in the chipped wood storage area pond prior to discharge to Outfall NP-0003. See Table 7-2 for limits.
--- Not Applicable.

TABLE 7-2 Treated Effluent Parameter Limits and Monitoring Requirements for Quarry Water Treatment Plant (NPDES Permit MO-0108987) and Site Water Treatment Plant (NPDES Permit MO-0107701)

PARAMETER	LOCATION NP-0007* NP-1001*	PARAMETER	LOCATION NP-0007* NP-1001*
Gross α	pCi/l[a]	Pb, total	0.10 mg/l
Gross ß	pCi/l[a]	Mn, total	0.10 mg/l
Uranium, total	pCi/l[a][b]	Hg, total	0.004 mg/l
Ra-226[c]	pCi/l[a]	Se, total	0.02 mg/l
Ra-228[c]	pCi/l[a]	Cyanide, Amenable	0.0075 mg/l
Th-230[c]	pCi/l[a]	2,4-DNT	0.22 µg/l
Th-232[c]	pCi/l[a]	Fluoride, total	4.0 mg/l
Flow	GPD[a]	Nitrate and Nitrite as N	20 mg/l[b]
COD	90/60 mg/l [e]	Sulfate as SO_4	500 mg/l
TSS	50/30 mg/l[e]	Chloride	mg/l[a]
pH	6-9 standard units	Priority Pollutants[f][l]	mg/l[a][h][l][n]
As, total	0.10 mg/l	Whole Effluent Toxicity	[i][j]
Cr, total	0.1 mg/l	Po-210[d]	pCi/l[a][b][h]
Cu[a][g]	1.00 mg/l	Ac-227[d]	pCi/l[a][b][h]
Cu-Site	1.0/0.66 mg/l[e][g][k]	Radon[d]	pCi/l[a][b][h]
Zn-Site	5.0/3.33 mg/l[e][g][k]	Creosote-site[f]	[m][k]

NOTE: Refer to Figure 7-2 for NPDES monitoring locations
* Frequency = once per batch unless otherwise noted.

(a) Monitoring only.
(b) Water treatment plants designed for an average concentration of 30 pCi/l (1.11 Bq/l) and never to exceed concentrations of 100 pCi/l (3.7 Bq/l).
(c) Once/month
(d) Quarry only.
(e) Daily maximum/monthly average.

TABLE 7-2 Treated Effluent Parameter Limits and Monitoring Requirements for Quarry Water Treatment Plant (NPDES Permit MO-0108987) and Site Water Treatment Plant (NPDES Permit MO-0107701) (Continued)

(f) Includes priority pollutant metals, total phenols, and total cyanide with reissuance of the NPDES permits. Priority pollutants are listed in 40 CFR 122.21 Appendix D, Tables II and III.)
(g) Limit applies to chemical plant; monitoring only at quarry.
(h) Annual monitoring.
(i) Quarterly monitoring.
(j) "No statistical difference between effluent and upstream results at 95% confidence level."
(k) Once per batch for each batch sampled within a period of 30 days following introduction of CWSA water (which has failed these limits) to the SWTP.
(l) Includes: acenapthylene, acenaphthene, benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(a)pyrene, benzo (k) fluoranthene, chrysene, fluoranthene, fluorene, indeno (1,2,3-cd) pyrene, naphthalene, and phenanthrene.
(m) Daily maximum - 2.5 x Q.L., monthly average - 1.5 x Q.L. Q.L. - quantification level as set by most recent edition of Standard Methods (Q.L. taken as practical quantification limit [PQL]).
(n) Polychlorinated biphenyls (PCBs) have a limit of 1 μg/l.

on March 4, 1994, and June 10, 1994, respectively. Permit MO-0107701 was revised on August 4, 1995.

The borrow area and borrow area haul road land disturbance storm water permit, MO-R100B69, issued September 1, 1994, has no specified monitoring or reporting requirements. A program was developed in the *Environmental Monitoring Plan* for monitoring settleable solids and, under certain circumstances, oil and grease. The results of this monitoring were used to measure the effectiveness of erosion control and improve controls if required. Permit MO-G679035, issued August 31, 1994, is for hydrostatic test water from site water treatment plant Train 2 plant and facilities construction. This permit requires sampling once per release for total suspended solids (TSS), oil and grease, and flow and reporting analytical results within 30 days of discharge. There were two discharges under NPDES permit MO-G679035 during 1995, with all parameters in compliance with permit limits. This permit was terminated on November 27, 1995. There will be no further discharges.

Effluent discharges are also regulated by Department of Energy (DOE) Order 5400.5, which calls for a best available technology evaluation if the annual average uranium concentration at the outfall exceeds the derived concentration guideline (DCG) for natural uranium (600 pCi/l [22.2 Bq/l]). Measures are also taken to keep uranium concentrations as low as reasonably achievable (ALARA).

The primary criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards for drinking water supplies established under the Missouri Clean Water Commission Regulation (10 CSR 20-7.031) and the U.S. Environmental Protection Agency primary and secondary maximum contaminant level concentrations for drinking water. A table of applicable water standards that includes contaminants routinely monitored in the surface water program can be found in Section 8.

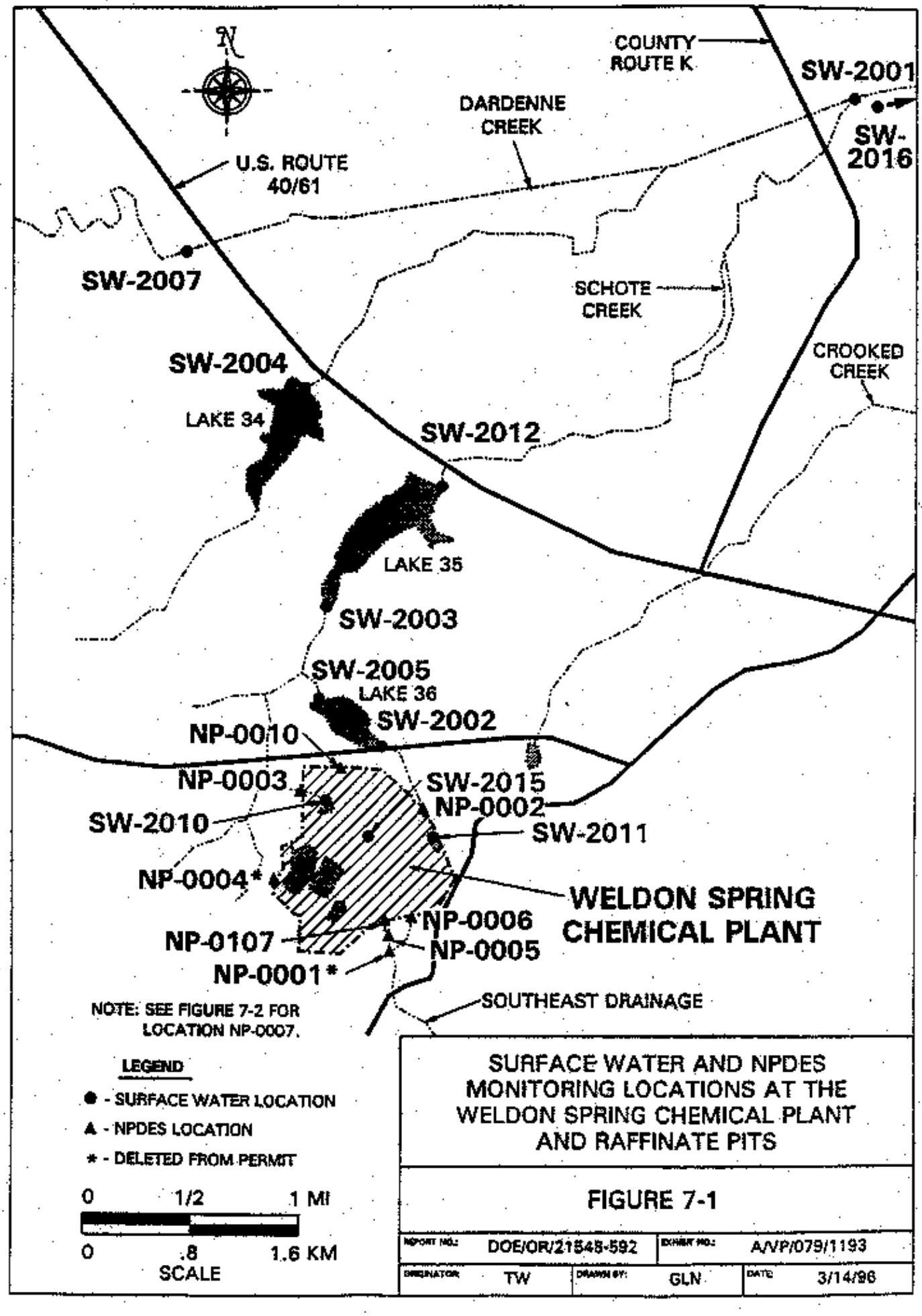
Surface water, other than NPDES outfalls, is also monitored under the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates DCGs for ingestion of water.

7.3 Hydrology Description of the Site and Quarry

Separate surface water monitoring programs have been developed at the chemical plant and quarry due to differences in the topography and hydrologic conditions. Both programs take into account the mechanisms controlling surface water source areas.

7.3.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits

The chemical plant area is located on the Missouri-Mississippi Rivers surface drainage divide. The topography is gently undulating and generally slopes northward to the Mississippi River. Streams do not cross the property, but incipient drainageways convey surface water runoff to off-site streams. Surface drainage from the northern and western portions of the site drain to tributaries of Busch Lake 35 and then to Schote Creek, which in turn enters Dardenne Creek, ultimately draining to the Mississippi River (Figure 7-1). Surface drainage from the chemical plant's abandoned storm water sewer and Frog Pond also discharges to Dardenne Creek after flowing through Busch Lakes 35 and 36 and into Schote Creek. Runoff from the southern portion of the chemical plant site flows southeast to the Missouri River via the Southeast Drainage (Valley 5300). During late 1995 two sedimentation ponds were constructed and placed in operation. One is upstream of Outfall NP-0003 and receives all the flow from the watershed prior to discharging to the outfall. The other is in the northeast section of the site and presently



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS

FIGURE 7-1

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/VP/079/1193
ORIGINATOR:	TW	DRAWN BY:	GLN
DATE:	3/14/96		

receives part of the runoff from the Frog Pond watershed. In the future, it will receive all runoff except that from the PMC and subcontractor parking lot.

The four raffinate pits, located in the southwestern portion of the chemical plant area, do not discharge to the surface and collect only direct precipitation. Water from the raffinate pits has been, and will be, treated at the site water treatment plant before release. The material staging area (MSA) basin (SW-2015) is a temporary holding pond that collects storm water runoff from the staging area. After monitoring for uranium and meeting the specified release level of less than 600 pCi/l (22.2 Bq/l), this impoundment is periodically pumped into the Ash Pond diversion channel, which flows to NPDES Outfall NP-0003 and then to Busch Lake 35.

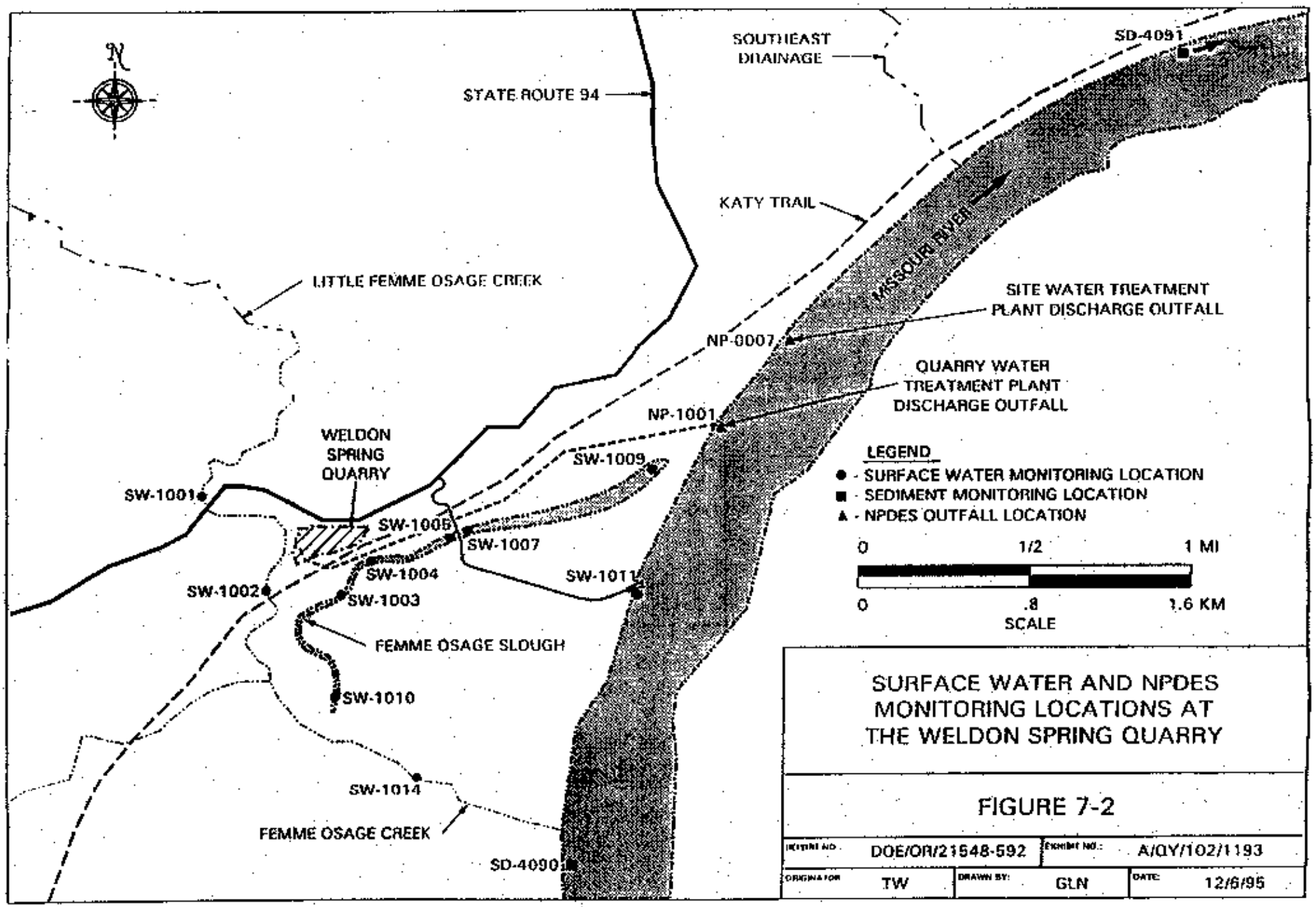
7.3.2 Weldon Spring Quarry

Surface water bodies in the quarry area are the Femme Osage Slough, the Little Femme Osage Creek, and the Femme Osage Creek (Figure 7-2). These water bodies do not receive direct runoff from the quarry, but are sampled to monitor potential changes due to the movement of contaminated groundwater from the fractured bedrock of the quarry through the fine-grained alluvial materials.

The Femme Osage Slough is located directly south of the quarry and is known to receive contaminated groundwater from the quarry through subsurface recharge. There is no natural flow from the slough; it is essentially land locked. The Little Femme Osage Creek is located west of the quarry and discharges into the Femme Osage Creek approximately 0.5 km (0.3 mi) southwest of the quarry. The Femme Osage Creek then flows into the Missouri River. Although there has been no evidence of impact from contaminated groundwater on the creeks via stream emergence, they are monitored to detect any changes in the system.

7.4 Monitoring

Sections 7.4.1 and 7.4.2 discuss monitoring requirements at NPDES outfalls and surface water locations at the chemical plant site and the quarry.



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 7-2

DESIGN NO:	DOE/OR/21548-592	Exhibit No.:	A/QY/102/1193		
ORIGINATOR:	TW	DRAWN BY:	GLN	DATE:	12/6/95

7.4.1 National Pollutant Discharge Elimination System Monitoring

The NPDES permits issued to the site identify the parameters to be monitored. Basic physical, chemical, and radiological parameters were monitored at all storm water outfalls. Additional parameters were monitored in the quarry water treatment plant and site water treatment plant effluents and in storm water samples collected for establishing baseline contaminant levels prior to future remedial actions.

In addition to the permitted outfalls, samples were collected upstream of NPDES storm water Outfalls NP-0002, NP-0003, and NP-0005 from sampling locations SW-2011 (Frog Pond), SW-2010 (Ash Pond), and NP-0107 respectively. Quarterly samples were also collected from the MSA pond and Ash Pond, when possible, to monitor the effects of materials stored in those areas on contaminant levels in the storm water runoff.

7.4.2 Surface Water Monitoring

The following two subsections discuss surface water monitoring requirements at the chemical plant site and the quarry.

7.4.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits. Under the surface water monitoring program Dardenne Creek, and Busch Lakes 34, 35, and 36 were sampled semiannually for total uranium. This monitoring was conducted to measure the effects of surface water discharges from the site on downstream surface water. The raffinate pits were previously monitored as surface water but are now monitored under treatment plant operations sampling. Previously, the MSA, Ash Pond, and Frog Pond were sampled under the surface water program, but they are now monitored in conjunction with the NPDES program because they discharge to NPDES permitted outfalls.

7.4.2.2 Weldon Spring Quarry. Seven locations within the Femme Osage Slough were monitored to determine the impact of groundwater migration from the quarry. Two locations on the Little Femme Osage Creek and one location at the Femme Osage Creek were monitored to provide data to determine if there is impact on these surface waters from the quarry.

Surface water locations SW-1003, SW-1004, and SW-1005 (Figure 7-2) were monitored bimonthly for total uranium because of past significant contaminant levels in these areas, fluxuations in concentrations due to changes in water levels in the slough and groundwater potentiometric surface, and the potential for these surface water contaminants to impact groundwater south of the slough. The remaining locations were sampled quarterly to provide sufficient data to determine any changes in these areas. Locations SW-1003, SW-1004, and SW-1005 were also monitored quarterly for nitroaromatic compounds because these locations are downgradient from the area of greatest nitroaromatic groundwater contamination. Nitroaromatic monitoring was deleted from the remaining locations based on sufficient past data indicating no impact and no potential for impact without first detecting contaminants at surface water locations closer to the source.

7.5 Monitoring Results

Analytical results of the monitoring of surface water and NPDES outfalls are presented in the following subsections.

7.5.1 National Pollutant Discharge Elimination System Program Monitoring Results

Radiochemical, chemical and physical analytical results for NPDES outfalls are presented in subsections 7.5.1.1 and 7.5.1.2.

7.5.1.1 Radiochemical Analysis. The 1995 average uranium concentrations at the storm water discharge points ranged from 67.2 pCi/l (2.49 Bq/l), at NP-0003 to 127.7 pCi/l (4.72 Bq/l) at NP-0005, which are 9.9% and 18.8%, respectively, of the DCG for natural uranium. Average annual gross alpha concentrations ranged from 127.4 pCi/l (4.72 Bq/l) at NP-0010 to 330.5 pCi/l (12.23 Bq/l) at NP-0005. The annual average radionuclide concentrations for all the permitted storm water outfalls are shown in Table 7-3. Uranium concentration averages were calculated on a flow proportional basis except for Outfall NP-0010 where there is no totalizing flow meter or flow measuring device. Flow weighted averages for uranium were calculated for the three major outfalls to give a more accurate estimate (than a straight average) of the total uranium that migrated off site during 1995. The averages were flow weighted by summing the total daily flows for the days the samples were collected and summing the total activity (pCi) for the days the samples were collected. The sum of the

TABLE 7-3 1995 Annual Average NPDES Results for the Weldon Spring Chemical Plant Storm Water Outfalls

LOCATION	NUMBER OF SAMPLE EVENTS	PH RANGE	TOTAL URANIUM (pCi/l)	GROSS ALPHA (pCi/l)	NITRATE NITRITE AS N (mg/l)	IONS	TOTAL SUSPENDED SOLIDS (mg/l)	SETTLEABLE SOLIDS (ml/l)
NP-0002	11	(a)	124.5*	174.8	0.4	[b]	33.3	<0.1
NP-0003	9	(a)	67.2*	190.6	1.6	NS	33.4	<0.1
NP-0005	11	(a)	127.7*	330.5	0.3	NS	26.4	<0.1
NP-0010	6	(a)	106.9	127.4	0.9	NS	67.0	<0.1

(a) All pH readings were in permitted range of 6.0 to 9.0.
(b) One sample collected Cl = 102 mg/l, F = <0.25 mg/l, SO_4 = 41.4 mg/l.
* Flow proportional averages.
NS Not Sampled.
Note: 1 pCi/l = 0.037 Bq/l

activity for all samples was then divided by the sum of the flow for all samples, to give the flow weighted average for the year.

The site water treatment plant (SWTP) and quarry water treatment plant (QWTP) were both in operation during 1995. Fourteen batches were discharged from the QWTP and 24 batches were discharged from the SWTP. No daily maximum or monthly average limits are established for uranium; however, the design of the treatment plant is based on achieving an average discharge of 30 pCi/l (1.11 Bq/l) uranium with a maximum never to exceed 100 pCi/l (3.7 Bq/l). The average uranium concentrations for the site and quarry water treatment plants were well below this level at 0.46 pCi/l (0.017 Bq/l) and 1.76 pCi/l (0.065 Bq/l), respectively. In addition, the SWTP averaged 2.42 pCi/l (0.09 Bq/l) for gross alpha and 11.62 pCi/l (0.4 Bq/l) for gross beta. The QWTP averaged 2.25 pCi/l (0.08 Bq/l) and 7.21 pCi/l (0.27 Bq/l), respectively for these same parameters. In addition to effluent monitoring, the NPDES permit for the quarry, MO-0108987, required that river sediment sampling be conducted upstream and downstream of the quarry water treatment plant outfall (NP-1001) annually. The river sediment was sampled for uranium at locations SD-4090 (upstream) and SD-4091 (downstream) (see Figure 7-2). The one-time sampling results were 1.3 pCi/g (0.05 Bq/l) at SD-4090 and 1.8 pCi/g (0.07 Bq/l) at SD-4091.

Radium and thorium were monitored once per month in both site and quarry water treatment batches with no elevated levels noted. Annual averages are shown in Table 7-4.

TABLE 7-4 Site and Quarry Water Treatment Plant Annual Averages for Radium and Thorium (pCi/l)

PARAMETER	QUARRY WTP NP-1001	SITE WTP NP-0007
Ra-226	0.42 (8/10)*	0.80 (7/12)
Ra-228	1.71 (8/10)	1.60 (9/12)
Th-228	0.41 (9/10)	0.35 (10/12)
Th-230	0.40 (8/10)	0.67 (9/12)
Th-232	0.36 (10/10)	0.29 (12/12)

* Number of results below detection limit/total number of samples.
Note: 1 pCi/l = 0.037 Bq/l

Actinium-227, Polonium-210 and Radon-222 were monitored one time in 1995 (as required) in the quarry effluent with values of (<17.7 pCi/l [0.655 Bq/l]) 0.148 pCi/l (0.005 Bq/l), and 3.9 pCi/l (0.144 Bq/l), respectively. The values for polonium and radon are below detection limits (uncensored values).

Estimated quantities of total natural uranium released off site through surface water runoff and treatment plant discharges are presented in Table 7-5. The total volume of storm water at the three major outfalls was measured with totalizing flow meters. Where flow meters were not available or not operational, the flow was determined by total precipitation and runoff curve numbers cited in the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 34). Total uranium released from the treatment plants was calculated using flow meter

TABLE 7-5 1995 Estimated Annual Release of Natural Uranium from NPDES Outfalls

OUTFALL	DRAINAGE AREA ACRES (HECTARES)	ESTIMATED % OF PRECIPITATION AS RUNOFF	AVERAGE CONCENTRATION (PCI/L)	TOTAL RAINFALL VOLUME (Mgal/yr)	TOTAL RUNOFF (Mgal/yr)	TOTAL U RELEASE (Ci/yr)	TOTAL U RELEASE (Kg/yr)
NP-0002	75.1 (30.4)	[a]	124.5*	80.06	29.73	14.03×10^{-3}	20.632
NP-0003	74.6 (30.2)	[b]	67.2*	79.53	33.57	8.54×10^{-3}	12.568
NP-0005	20.2 (8.2)	[b]	127.7*	21.53	7.00	3.39×10^{-3}	4.986
NP-0010	5.0 (2.0)	20[a]	106.9	5.33	1.07	0.433×10^{-3}	0.637
NP-0007	N/A	N/A	0.5	N/A	33.81	0.058×10^{-3}	0.086
NP-1001	N/A	N/A	1.8	N/A	11.11	0.074×10^{-3}	0.109
TOTAL	N/A	N/A	N/A	186.45	116.29	26.5×10^{-3}	39.017

(a) Runoff curve number estimated from U.S. Department of Transportation *Design of Roadside Drainage Channels* (Ref. 55).
(b) Total runoff measured from flow meters.
N/A Not Applicable.
Note: To convert from Ci/yr to Bq/yr multiply Ci/yr by 3.7×10^{10}
* Flow weighted average.

and effluent concentration data. The estimated mass of uranium released off site in storm water and treated effluent during 1995 was 39.017 kg (26.5×10^{-3} Ci). This is a 62.3% reduction from the calculated amount released during 1994. This reduction may be attributed to the capping of Ash Pond, the removal of all site buildings, and precipitation patterns. During 1995, there were few major precipitation events, and most events were light and widely scattered, which allowed the soil to become dry between events. This could have reduced runoff during the events. The light, scattered events also prevented the soil from remaining saturated for long periods of time. It appears, from past observation, that saturation of contaminated soils for long periods allows greater quantities of uranium to go into solution. If precipitation then occurs the runoff has higher uranium concentrations than normal.

Annual average uranium concentrations for NPDES outfalls from 1991 to 1995 are shown in Table 7-6. Concentrations in 1995 increased at Outfall NP-0010; decreased at Outfalls NP-0002, NP-0003, and NP-0005; and did not change appreciably at NP-0007 and NP-1001, compared to 1994 concentrations. The first year for sampling Outfall NP-0010 was 1993. Each outfall is discussed individually below.

TABLE 7-6 Five-Year Annual Average Uranium Concentrations at NPDES Outfalls

OUTFALL	ANNUAL AVERAGE TOTAL URANIUM (pCi/l)				
	1991	1992	1993	1994	1995
NP-0001	475	516	1003*	1226*	(a)
NP-0002	158	228	230*	182*	124*
NP-0003	456	478	607*	332*	67*
NP-0004	6	6	9*	12*	--
NP-0005	581	296	133*	347*	128*
NP-0010	--	--	--	82	107
NP-0007	--	--	0.363	0.74	0.46
NP-1001	--	<0.0003	1.881	1.60	1.76

* Flow proportional average.
-- Not applicable.
(a) Outfall removed, flow diverted to NP-0005.

Outfall NP-0001 was the outlet of an abandoned process sewer outfall pipeline. Outfall NP-0001 was effectively eliminated during May 1994 when the outfall line was removed. This outfall was officially eliminated from the permit on August 4, 1995. There was no discharge during 1995.

The average uranium concentration for Outfall NP-0002 in 1995 was 124 pCi/l (4.6 Bq/l), somewhat less than the 1994 average of 182 pCi/l (6.7 Bq/l). This reduction may be the result of precipitation patterns (as discussed above) and the lack of site activity in the watershed. The completion of a sedimentation basin late in the year had little effect, since it was not in use for most of the year.

The average uranium concentration for Outfall NP-0003 was 67 pCi/l (2.5 Bq/l), which was greatly reduced from the 1994 average of 332 pCi/l (12.3 Bq/l). The uranium levels were reduced due to the Ash Pond area becoming a managed area during 1994. The DOE requires that water from a managed area be less than 600 pCi/l (22.2 Bq/l) before discharge from the managed area. In the past, uranium concentrations were often greater than 600 pCi/l (22.2 Bq/l)

from Ash Pond. The South Dump area of the pond and the pond bottom were also capped with soil to help reduce uranium levels and eliminate the ponding of water in Ash Pond. The construction of a sedimentation basin immediately upstream of the outfall may also have helped reduce concentrations in the later part of the year.

Outfall NP-0004 was eliminated from NPDES permit MO-0107701 March 4, 1994, and no samples were collected for 1995.

The annual average uranium concentration at Outfall NP-0005 for 1995 was 128 pCi/l (4.7 Bq/l), which was significantly less than the 1994 average of 347 pCi/l (12.8 Bq/l). The uranium concentrations at this outfall are highly variable due to the two sources that contribute to the outfall; a sedimentation basin that has very low levels of uranium and an area that has high concentrations of uranium during low flow runoff. The Project Management Contractor (PMC) has taken measures to reduce uranium levels at NP-0005 (e.g., plugging storm sewers, capping contaminated soil areas, etc.), which has helped reduce the uranium concentration. Precipitation patterns may also have contributed to decreased concentrations for 1995.

Outfall NP-0010 was added to NPDES permit MO-0107701 when it was reissued March 4, 1994. There are limited 1994 data for comparison. This outfall is located at the west end of the north perimeter fence in the proposed construction materials staging area (CMSA), and drains a shallow wooded swale where there was often no discharge. The annual average uranium concentration was 107 pCi/l (4.0 Bq/l), well below the DCG of 600 pCi/l (22.2 Bq/l) but somewhat higher than the 1994 average of 82 pCi/l (3.0 Bq/l). The NP-0010 watershed was cleared and grubbed during 1995 in preparation for development of the CMSA. The increased soil exposure may have contributed to the increase in average uranium concentration.

In addition to uranium and gross alpha, Outfalls NP-0002, NP-0003, and NP-0005 were sampled monthly for Ra-226, Ra-228, Th-228, Th-230, and Th-232 beginning with the September 1994 sampling events and continuing through February 1995. The results of this sampling are discussed in Section 11.3 (Special Studies).

The MSA pond (SW-2015) was sampled quarterly for gross alpha, uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232 to monitor the effects of MSA discharges on NPDES Outfall NP-0003. The uranium average was 110.1 pCi/l (4.1 Bq/l), well below the release

criteria of 600 pCi/l (22.2 Bq/l) (the DCG for uranium). Radium and thorium were measured to be at low levels. The results are reported in Table 7-7.

TABLE 7-7 MSA, Ash Pond and Frog Pond - 1995 Annual Average Radiological Concentrations (pCi/l)

LOCATION PARAMETER	ASH POND SW-2010	MSA POND SW-2015	FROG POND SW-2011
Ra-226	0.57	0.64	N.S.
Ra-228	1.44	0.62	N.S.
Th-228	0.16	0.18	N.S.
Th-230	0.85	0.51	N.S.
Th-232	0.18	0.13	N.S.
U	475.17	110.10	286.70
Gross alpha	286.38	112.28	246.67

N.S. Not Sampled.

Ash Pond (SW-2010) was sampled quarterly, when water was present, for gross alpha, uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232 to monitor the effects of demolition debris and soil stored in Ash Pond on Ash Pond runoff and subsequently, on Outfall NP-0003. Radium and thorium were measured at low levels. The average results are reported in Table 7-7.

Frog Pond was sampled for uranium and gross alpha in conjunction with NPDES sampling at Outfall NP-0002 for uranium and gross alpha. Results were similar to values at Outfall NP-0002 and are reported in Table 7-7.

7.5.1.2 Physical and Chemical Results.

Analytical results for physical and chemical (as opposed to radiochemical) parameters at NPDES outfalls are presented in subsections 7.5.1.2.1 through 7.5.1.2.3.

7.5.1.2.1 Chemical Plant Storm Water. The annual averages for the physical and chemical parameters for storm water Outfalls NP-0002, NP-0003, NP-0005, and NP-0010 are shown in Table 7-3. In addition to the permitted parameters, Outfalls NP-0002, NP-0003, and NP-0005 were sampled monthly for 2,4-dinitrotoluene (DNT), 2,4,6-trinitrotoluene (TNT), Hazardous Substance List (HSL) metals, polychlorinated biphenyls (PCBs), and polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) starting in September 1994. The results of this sampling are discussed in Section 11.1.3.

Ash Pond (SW-2010) was sampled quarterly for PAHs, As, Cr, Tl, Pb, 2,4-DNT, and 2,4,6-TNT to monitor the effect of demolition debris and soils in Ash Pond on contaminants in the Ash Pond storm water runoff. None of these parameters were measured at elevated levels. If it appears that contaminant concentrations are increasing, monitoring frequencies are increased. If increased monitoring indicates that the water would adversely affect Outfall NP-0003, a valve in the Ash Pond discharge structure will be closed and the water retained. Analytical results are shown in Table 7-8.

The MSA Pond (SW-2015) was sampled quarterly for the same parameters as Ash Pond to monitor the effects of material stored on the MSA on storm water runoff to the pond. None of the contaminants were detected at elevated levels. The monitoring results are used to determine if the MSA water would have an adverse effect on Outfall NP-0003. If it appears that contaminant concentrations are increasing, then monitoring frequencies are increased and water that would adversely effect Outfall NP-0003 is not released. Results are shown in Table 7-8.

7.5.1.2.2 Administration Building Sewage Treatment Plant. Monitoring results for sewage treatment plant Outfall NP-0006 are given in Table 7-9. During February, one noncompliance with permit limits occurred for biochemical oxygen demand (BOD) and three noncompliances with permit limits occurred for total suspended solids (TSS). During October, one noncompliance for fecal coliform occurred. The subcontractor has made operational changes to bring the plant into compliance. Sampling techniques for fecal coliform were also improved.

TABLE 7-8 Ash and MSA Pond - 1995 Annual Average Chemical Concentrations (μg/l)

LOCATION PARAMETER	SW-2010	SW-2015
PAHs	<23*	<23*
As	5.90	2.85
Cr	8.80	6.76
Tl	36.10	2.63
Pb	6.95	19.83
PCBs	0.44	0.46
2,4-DNT	0.04	0.02
2,4,6-TNT	0.16	0.02

* All N.D. with 23 μg/l being the highest detection limit.

TABLE 7-9 NP-0006, Sewage Treatment Plant Outfall, Monthly Averages of Permitted Parameters

	PARAMETER[a] (PERMIT LIMITS)			
MONTH	TSS (15/20 mg/l)*	BOD (10/15 mg/l)*	FC[b] (400/1000 col/100 ml)**	pH (6.0-9.0 SU)
January	NS	NS	NS	6.2 (1)
February	27.33 (3)	10.67 (3)	260 (1)	8.0 (1)
June	10 (1)	8.2 (1)	<1 (1)	7.00 (1)
August	6 (1)	4.3 (1)	<2 (1)	6.49 (1)
October	8.0 (1)	4.18 (1)	7,500*** (2)	6.01 (1)

(a) Number of samples given in parentheses after average.
(b) F.C - fecal coliform.
NS Not Sampled
* Monthly average/weekly average; changed to 30/45 mg/l on August 4, 1995
** Monthly average/daily maximum
*** Sample results were 15,000 and <1

7.5.1.2.3 Site and Quarry Water Treatment Plant Physical and Chemical Parameters. Physical and chemical parameters were all within permitted limits (where limits were assigned) for the site and quarry water treatment plants.

During 1995, whole effluent toxicity (WET) tests were required quarterly for both site water treatment plant, and quarry water treatment plant effluent. The WET test is a measure of toxicity without quantifying or identifying the toxic constituents. Tests were conducted on both Ceriodaphnia dubia (water flea) and Pimephales promelas (fathead minnow). The tests were conducted in effluents and in test controls of upstream river water and laboratory control water. No effluent samples failed the WET tests during 1995 indicating that the site and quarry water treatment plant effluents were not toxic to test organisms. Whole effluent toxicity test results are summarized in Table 7-10.

TABLE 7-10 1995 Whole Effluent Toxicity Test Results for the Site and Quarry Water Treatment Plants

BATCH	DATE	DAPHNIA C (D)% MORTALITY	PIMEPHALES (P) % MORTALITY	RIVER CONTROL D,P % MORTALITY	LAB CONTROL D,P % MORTALITY
S049	01/18/95	0	2.5	0,5	0,5
S055	03/27/95	0	0	0,0	0,0
S064	07/17/95	5	0	0,5	5,0
S069	11/06/95	0	0	0,0	0,0
Q029	02/13/95	0	0	0,0	0,0
Q032	04/24/95	0	0	0,0	0,0
Q039	08/21/95	5	0	0,0	0,7.5
Q041	11/07/95	5	0	0,0	0,0

P Pimephales
D Daphnia (Ceriodaphnia)

7.5.2 Surface Water Monitoring Results

Analytical results for surface water monitoring locations at the chemical plant site and quarry are presented in subsections 7.5.2.1 and 7.5.2.2.

7.5.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits. Uranium levels at off site surface water locations were generally reduced from the 1994 annual averages. This general reduction was the result of the completion of building demolition at the chemical plant and a reduction in uranium migrating off site through NPDES outfalls. Average annual uranium concentrations for surface water are shown in Table 7-11 along with the historic high for the location for comparison. Surface water locations are shown in Figure 7-1.

TABLE 7-11 Annual Averages for Total Uranium (pCi/l) Concentrations at Weldon Spring Chemical Plant Area Surface Water Locations

LOCATION	AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-2001	1.8	2.4	1.16	10
SW-2002	35.9	40.3	31.5	390 (1994)
SW-2003	6.4	8.3	4.45	69
SW-2004	7.1	7.9	6.23	39
SW-2005	32.2	35.6	28.8	53.7
SW-2012	[a]	[a]	[a]	326 (1991)
SW-2016	1.6	2.0	1.12	7.8

(a) No samples collected, no flow from lake.
Note 1: 1 pCi/l = 0.037 Bq/l.
Note 2: Two samples were collected at all locations except SW-2012.

7.5.2.2 Weldon Spring Quarry.

Total Uranium. The average total uranium values continue to indicate that the highest levels are found in the portion of the Femme Osage Slough (SW-1003, SW-1004 SW-1005 and SW-1010) down-gradient of the quarry. The annual averages for the surface water locations are

summarized in Table 7-12. The uranium levels in the Femme Osage Slough are within historical ranges. The total uranium levels in the Little Femme Osage Creek and the Femme Osage Creek remained at background levels.

TABLE 7-12 Annual Averages for Total Uranium (pCi/l) at Weldon Spring Quarry Surface Water Monitoring Locations

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM	HISTORIC HIGH
SW-1001*	0.46	1.2	0.05	13.0
SW-1002*	0.37	0.8	0.05	11.5
SW-1003	32.38	52.6	8.0	252 (1989)
SW-1004	32.35	49.6	7.2	4000 (1993)
SW-1005	18.05	30.5	6.3	116 (1991)
SW-1007	8.45	16.3	2.10	69
SW-1009	5.74	10.0	1.70	28.6
SW-1010	18.18	51.5	3.5	156 (1991)
SW-1014*	1.32	2.6	0.05	4.08

Note: 1 pCi/l = 0.037 Bq/l
* Creek locations

The DOE dose limit for total uranium in drinking water systems is 24 pCi/l (0.89 Bq/l), which is 4% of the DCG for total uranium (600 pCi/l [22.2 Bq/l]). This value was used for comparison purposes for the Little Femme Osage Creek (SW-1001 and SW-1002) and the Femme Osage Creek (SW-1014). This value was not exceeded in any of the creek samples. Furthermore, the proposed U.S. Environmental Protection Agency Drinking Water Standard of 20 μg/l (13.6 pCi/l) for total uranium was not exceeded at any of the creek monitoring locations.

Nitroaromatic Compounds

Nitroaromatic compounds were analyzed at SW-1003, SW-1004, and SW-1005 in the Femme Osage Slough. No detectable levels for any of the six compounds monitored were observed.

7.6 Highlights of the Surface Water Program

- The mass of uranium migrating off site in storm water and treated effluent was reduced by 62.3% over the 1994 mass.
- Thirty-eight batches of water were released from the site and quarry water treatment plants during 1995 with no NPDES permit violations.
- The overall results of the WET tests indicate that the site and quarry water treatment plant effluent was not toxic to test organisms during 1995.
- Total uranium levels in the Femme Osage Creek and Little Femme Osage Creek were at background.
- No detectable concentrations of nitroaromatic compounds were observed in the Femme Osage Slough.
- Total uranium levels in the Femme Osage Slough were within historical ranges.

8 GROUNDWATER MONITORING

8.1 Program Overview

The groundwater monitoring and protection program at the Weldon Spring Site Remedial Action Project (WSSRAP) includes sampling and analysis of water collected from wells at the Weldon Spring Chemical Plant and raffinate pits, the Weldon Spring Quarry, vicinity properties, and from selected springs in the vicinity of the Weldon Spring site. The groundwater protection program is formally defined in two documents: the *Groundwater Protection Program Management Plan* (Ref. 13) and the *Environmental Monitoring Plan* (Ref. 42).

Due to lithologic differences, including those geologic features that influence groundwater flow mechanics, and the geographical separation of the chemical plant and quarry area, separate groundwater monitoring programs have been established for the two sites. Generalized geologic and hydrologic descriptions of the two sites are found in Section 1.3. A generalized stratigraphic column for reference is provided in Figure 8-1, and hydrogeologic descriptions of lithologies monitored for the program are in Section 8.3.

8.2 Referenced Standards

Two main criteria were used to develop the groundwater monitoring program: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Water 1986* (Ref. 35), which is intended to protect public groundwater resources, and (2) the Missouri Drinking Water Standards (Ref. 36). These standards are mainly used for comparison of levels observed in the St. Charles County well field. Table 8-1 identifies EPA water quality standards and Missouri Drinking Water Standards for contaminants that are routinely monitored in the groundwater program. Maximum contaminant levels (MCLs) and other drinking water standards are used only as references by the WSSRAP. The affected groundwater does not represent a public drinking water supply as defined in 40 CFR, Part 141, Subpart A - General.

Groundwater is also monitored under the requirements of Department of Energy Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates derived concentration guidelines (DCGs) for ingestion of water equivalent to 100 mrem (1.0 mSv)

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (FT.)	LITHOLOGY	PHYSICAL CHARACTERISTICS	HYDROSTRATIGRAHIC UNIT
QUATERNARY	HOLOCENE	ALLUVION	0 - 120		GRAVELLY, SILTY LOAM.	ALLUVIAL AQUIFER
	PLEISTOCENE	LOESS AND GLACIAL DRIFT	10- 50	VARIABLE	SILTY CLAY, GRAVELLY CLAY, SILTY LOAM, OR LOAM OVER RESIDUUM FROM WEATHERED BEDROCK.	(UNSATURATED)
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION (2)	0 - 15		LIMESTONE, LIMEY DOLOMITE, FINELY TO COARSELY CRYSTALINE, MASSIVELY BEDDED, AND THIN BEDDED SHALE.	
		WARSAW FORMATION (2)	60 - 80		SHALE AND THIN TO MEDIUM BEDDED FINELY CRYSTALINE LIMESTONE WITH INTERBEDDED CHERT.	
	OSAGEAN	BURLINGTON AND KEOKUK LIMESTONES	100 - 200		CHERTY LIMESTONE, VERY FINE TO VERY COARSELY CRYSTALINE, FOSSILIFEROUS, THICKLY BEDDED TO MASSIVE.	SHALLOW AQUIFER SYSTEM
		FERN GLEN LIMESTONE	45 - 70		CHERTY LIMESTONE, DOLOMITIC IN PART, VERY FINE TO VERY COARSELY CRYSTALINE, MEDIUM TO THICKLY BEDDED.	
	KINDERHOOKIAN	CHOUTEAU LIMESTONE	20 - 50		DOLOMITIC, ARGILLACEOUS LIMESTONE; FINELY CRYSTALINE; THIN TO MEDIUM BEDDED.	UPPER LEAKY CONFINING UNIT
DEVONIAN	UPPER	SULPHUR SPRINGS GROUP BUSHBERG SANDSTONE (3)	40 - 80		QUARTZ ARENITE, FINE TO MEDIUM GRAINED, FRIABLE.	
		LOWER PART OF SULPHUR SPRINGS GROUP			CALCAREOUS SILTSTONE, SANDSTONE, OOLITIC LIMESTONE, AND HARD CARBONACEOUS SHALE.	
ORDOVICIAN	CINCINNATIAN	MAQUOKETA SHALE (4)	10 - 30		CALCAREOUS TO DOLOMITIC SILTY SHALE AND MUDSTONE, THINLY LAMINATED TO MASSIVE.	
	CHAMPLAINIAN	KIMMSWICK LIMESTONE	70 - 100		LIMESTONE, COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED, FOSSILIFEROUS AND CHERTY NEAR BASE.	MIDDLE AQUIFER SYSTEM
		DECORAH FORMATION	30 - 50		SHALE WITH THIN INTERBEDS OF VERY FINELY CRYSTALINE LIMESTONE.	LOWER CONFINING UNIT
		PLATTIN LIMESTONE	100 - 130		DOLOMITIC LIMESTONE, VERY FINELY CRYSTALLINE, FOSSILIFEROUS, THINLY BEDDED.	
		JOACHIM DOLOMITE	90 - 105		INTERBEDDED VERY FINELY CRYSTALLINE, THINLY BEDDED DOLOMITE; LIMESTONE; AND SHALE. SANDY AT BASE.	
		ST. PETER SANDSTONE	120 - 180		QUARTZ ARENITE, FINE TO MEDIUM GRAINED, MASSIVE.	DEEP AQUIFER SYSTEM
	CANADIAN	POWELL DOLOMITE	50 - 80		SANDY DOLOMITE, MEDIUM TO FINELY CRYSTALINE, MINOR CHERT AND SHALE.	
		COTTER DOLOMITE	200 - 250		ARGILLACEOUS, CHERTY DOLOMITE; FINE TO MEDIUM CRYSTALINE. INTERBEDDED WITH SHALE.	
		JEFFERSON CITY DOLOMITE	150 - 180		DOLOMITE, FINE TO MEDIUM CRYSTALINE.	
		ROUBIDOUX FORMATION	150 - 170		DOLOMITIC SANDSTONE.	
		GASCONADE DOLOMITE	250		CHERTY DOLOMITE AND ARENACEOUS DOLOMITE (GUNTER MEMBER).	
CAMBRIAN	UPPER	EMINENCE DOLOMITE	200		DOLOMITE, MEDIUM TO COARSELY CRYSTALLINE; MEDIUM BEDDED TO MASSIVE.	
		POTOSI DOLOMITE	100		DOLOMITE, FINE TO MEDIUM CRYSTALLINE, THICKLY BEDDED TO MASSIVE. DRUSY QUARTZ COMMON.	

(1) THICKNESS DATA SOURCES VARY. QUATERNARY UNIT THICKNESS BASED ON ON-SITE DRILLING AND TRENCHING. BURLINGTON AND KEOKUK THROUGH JOACHIN DOLOMITE BASED ON USGS WELLS MW-0502 AND 0505. ST. PETER SANDSTONE AND BELOW FROM KLEESCHULTE AND EMRELL (1987). WARSAW AND SALEM FORMATIONS FROM MISSOURI DNR-DGLS GEOLOGIC MAP OFM-88-282-GI (1989).

(2) THE WARSAW AND SALEM FORMATIONS ARE BELIEVED TO BE ABSENT FROM THE WELDON SPRING AREA DUE TO EROSION.

(3) THE SULPHUR SPRINGS GROUP ALSO INCLUDES THE BACHELOR SANDSTONE AND THE GLEN PARK LIMESTONE-MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY.

GENERALIZED STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

FIGURE 8-1

REPORT NO.	EXHIBIT NO.
DOE/OR/21548-592	A/PI/047/0391
ORTHOGRATOR: RCC	DRAWN BY: SRS
	DATE: 12/5/95

TABLE 8-1 Referenced Federal and State Water Standards

PARAMETER		LEVEL	REFERENCE STANDARD	PARAMETER		LEVEL	REFERENCE STANDARD
Radio-chemical	Uranium total[a,c]	20 µg/l (13.6 pCi/l)	EPA	Metals	Fe[d]	300 µg/l	MDWS
	Gross α (adjusted)[c]	15 pCi/l	MDWS		Pb[e]	15 µg/l	MDNR
	Ra-226[b,c]	5 pCi/l	MDWS		Mn[d]	50 µg/l	MDWS
	Rn-222[a,c]	300 pCi/l	EPA		Hg[c]	2.0 µg/l	MDWS
Misc.	2,4-DNT[e]	0.11 µg/l	MDNR		Ni[c]	100 µg/l	MDWS
	TDS[d]	500 mg/l	MDWS		Se[c]	50 mg/l	MDWS
Metals	Sb[c]	6.0 µg/l	MDWS		Ag[d]	100 µg/l	MDWS
	As[c]	50 µg/l	MDWS		Zn[d]	5.0 mg/l	MDWS
	Ba[c]	2 mg/l	MDWS				
	Be[c]	4.0 µg/l	MDWS	Anions	Cl[d]	250 mg/l	MDWS
	Cd[c]	5 µg/l	MDWS		F[d]	2.0 mg/l	MDWS
	Cr[c]	100 µg/l	MDWS		NO_3[c]	10 mg/l	MDWS
	Cu[d]	1.0 mg/l	MDWS		SO_4[d]	250 mg/l	MDWS

(a) Proposed.
(b) Standard for combined Ra-226 and Ra-228.
(c) Primary maximum contaminant level.
(d) Secondary maximum contaminant level.
(e) Water Quality Standard for Groundwater.
EPA EPA Drinking Water Standards for Radionuclides.
MDNR Missouri Department of Natural Resources
MDWS Missouri Drinking Water Standard.

effective dose equivalent, based on the consumption of 730 liters/year (193 gal/year) (Table 8-2). As specified in Department of Energy Order 5400.5, liquid effluent from U.S. Department of Energy (DOE) activities may not cause private or public drinking waters to exceed the radiological limit of an effective dose equivalent greater than 4 mrem (0.04 mSv/year) per year or 4% of the derived concentration guideline (DCG).

TABLE 8-2 Derived Concentration Guidelines for Discharge Waters

PARAMETER	DERIVED CONCENTRATION GUIDELINE
Natural Uranium	600 pCi/l
Ra-226	100 pCi/l
Ra-228	100 pCi/l
Th-230	300 pCi/l
Th-232	50 pCi/l

Note: 1 pCi/l = 0.037 Bq/l.

Upgradient-downgradient water quality comparisons are not practical for the chemical plant site because it sits atop a local groundwater high and straddles the regional groundwater divide (Ref. 37). Background values for uranium, nitrate, and sulfate were developed by the U.S. Geological Survey (USGS) for the shallow aquifer (Ref. 37) and are used in lieu of these comparisons.

8.3 Weldon Spring Chemical Plant

8.3.1 Hydrogeologic Description

The Weldon Spring Chemical Plant is located in a transitional area between the Dissected Till Plains of the central lowlands province to the north and the Salem Plateau of the Ozark Plateaus physiographic province to the south.

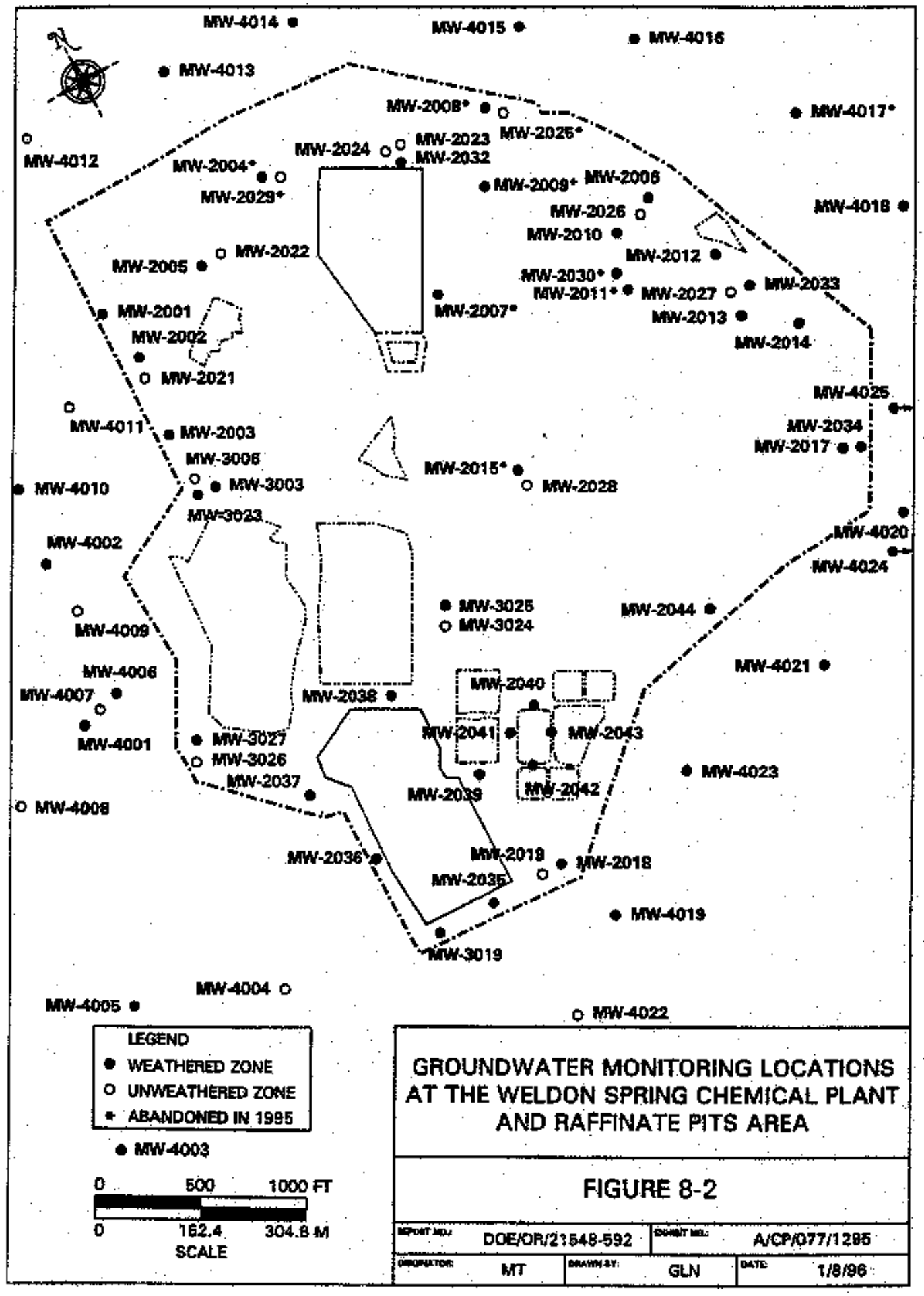
The chemical plant is located on a groundwater divide from which groundwater flows north toward Dardenne Creek and then ultimately to the Mississippi River, or south to the Missouri River. Regional groundwater flow for St. Charles County is towards the east. Localized flow is controlled largely by topographic highs and streams and drainages. Groundwater movement is generally by diffuse flow with localized zones of discrete fracture-controlled flow.

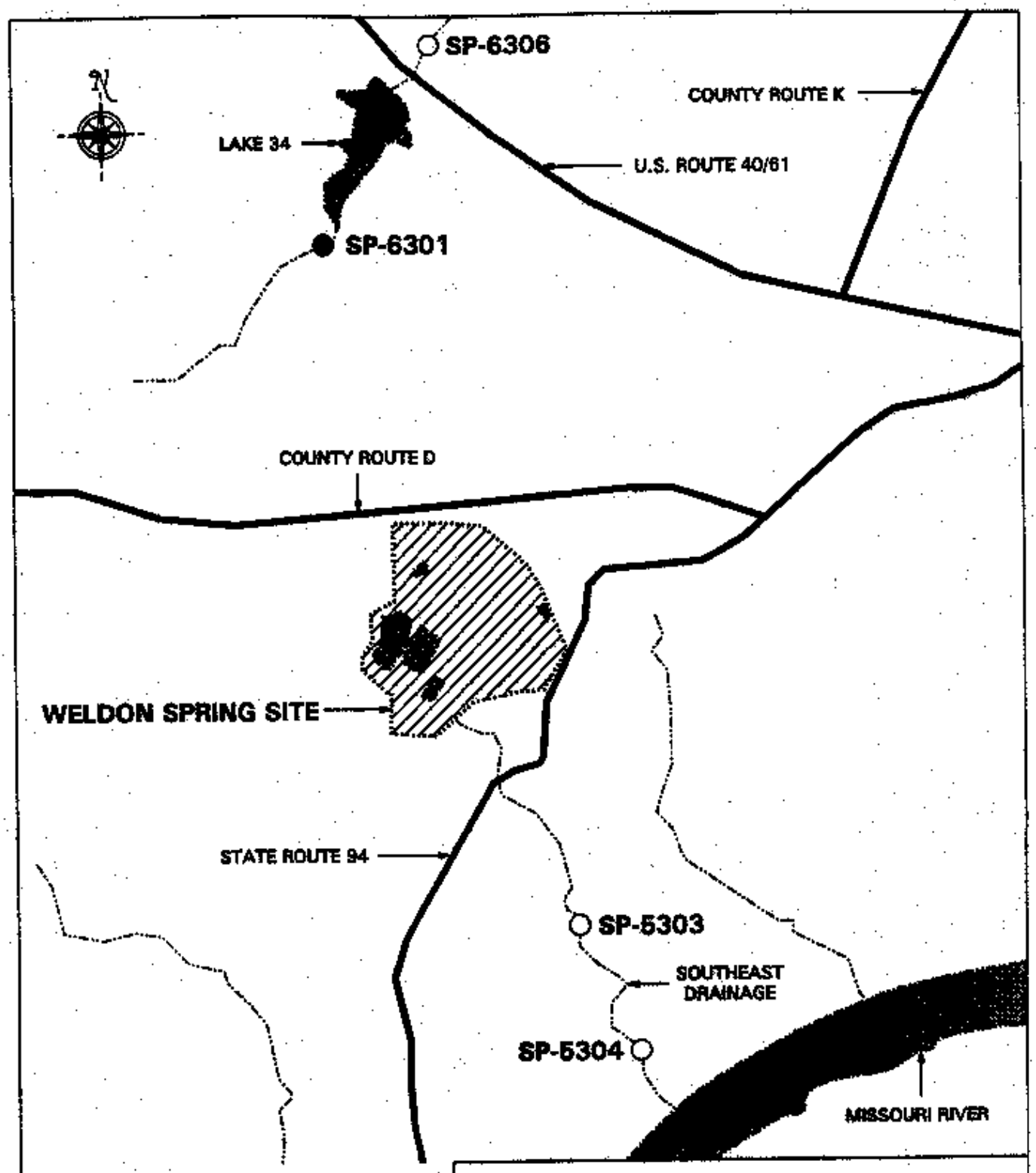
The chemical plant and raffinate pit area lithologies consist of two major geologic units; unconsolidated surficial material and carbonate bedrock. The unconsolidated surficial materials are clay-rich, mostly glacially derived units, which are generally unsaturated. Thicknesses range from 6.1 m to 15.3 m (20 ft to 50 ft) (Ref. 3).

The primary method of assessing potential groundwater impacts is monitoring groundwater from the monitoring well network at the site. The aquifer of concern beneath the chemical plant, raffinate pits, and vicinity properties is the shallow bedrock aquifer comprised of Mississippian-age Burlington-Keokuk Limestone (the uppermost bedrock unit) and the Fern Glen Limestone. The Burlington-Keokuk Limestone is composed of two different lithologic zones; a shallow weathered zone underlain by an unweathered zone. The weathered portion of this formation is highly fractured and exhibits solution voids and enlarged fractures. These features may also be found on a limited scale in the unweathered zone. The unweathered portion of the Burlington-Keokuk Limestone is thinly to massively bedded. Fracture densities are significantly less in the unweathered zone than in the weathered zone. Localized aquifer properties are controlled by fracture spacing, solution voids, and preglacial weathering including structural troughs along the bedrock-unconsolidated material interface.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Of the 74 monitoring wells, 19 are completed in the weathered zone, 35 are completed in both the weathered and unweathered zones (which primarily monitor the weathered zone), and 20 are completed in the unweathered zone. The wells in the unweathered zone of the Burlington-Keokuk Limestone are used to assess the vertical migration of contaminants. Where possible, monitoring wells within the boundaries of the chemical plant are located close to potential contaminant sources to assess migration into the groundwater system. Additional wells are located outside the chemical plant boundary to detect and evaluate potential off-site migration of contaminants (Figure 8-2).

Springs, a common feature in carbonate terrains, are present in the vicinity of the Weldon Spring site. Four springs are known to have been historically impacted by previous chemical plant operations and discharge water containing one or more of the contaminants of concern (Figure 8-3). Currently, Burgermeister Spring (SP-6301 on Figure 8-3) is monitored to determine contaminant off-site migration potential via spring transport.


MW-4014
MW-4015
MW-4016
MW-4013
MW-2008*
MW-4017*
MW-2025*
MW-2023
MW-2024
MW-2032
MW-4012
MW-2004*
MW-2029*
MW-2009*
MW-2006
MW-2026
MW-4018
MW-2010
MW-2022
MW-2012
MW-2005
MW-2030*
MW-2011*
MW-2027
MW-2033
MW-2007*
MW-2001
MW-2013
MW-2002
MW-2014
MW-2021
MW-4025
MW-4011
MW-2003
MW-2034
MW-2017
MW-3005
MW-2015*
MW-4010
MW-3003
MW-2028
MW-3023
MW-4020
MW-4002
MW-4024
MW-3025
MW-2044
MW-4009
MW-3024
MW-4021
MW-4006
MW-2040
MW-4007
MW-2038
MW-2041
MW-2043
MW-4001
MW-3027
MW-3026
MW-4023
MW-2037
MW-2039
MW-2042
MW-4008
MW-2036
MW-2019
MW-2018
MW-2035
MW-4019
MW-3019
MW-4004
MW-4005
MW-4022
LEGEND
WEATHERED ZONE
UNWEATHERED ZONE
ABANDONED IN 1995
MW-4003
0 500 1000 FT
0 152.4 304.8 M
SCALE
GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS AREA
FIGURE 8-2
REPORT NO.: DOE/OR/21548-592
SHEET NO.: A/CP/077/1285
ORIGINATOR: MT
DRAWN BY: GLN
DATE: 1/8/96



SPRING MONITORING LOCATIONS IN THE WELDON SPRING SITE AREA

FIGURE 8-3

REPORT NO.:	DOE/OR/21548-592	SHEET NO.:	A/VP/080/1193
ORIGINATOR:	MGL	DRAWN BY:	GLN
DATE:	5/10/96		

The presence of elevated total uranium and nitrate levels at Burgermeister Spring, which is located 1.9 km (1.2 mi) north of the site, indicates that discrete flow paths are present in the vicinity of the site.

8.3.2 Monitoring Program

8.3.2.1 Purpose. The 1995 groundwater monitoring program at the chemical plant and raffinate pits focused on contaminant monitoring and establishing pre-remedial action baseline characterization of groundwater. Total uranium, nitroaromatic compounds, sulfate, and nitrate at selected locations were monitored annually. Total uranium was analyzed in groundwater under the environmental monitoring program at the chemical plant in order to monitor potential groundwater uranium plume migration since 1994 and to further establish baseline uranium concentrations prior to source removal during remedial action. Due to the heterogeneity of uranium distribution in soils across the site, all active locations in the chemical plant groundwater monitoring network were analyzed for total uranium.

Groundwater in the vicinity of the raffinate pits is impacted with elevated nitrate concentrations. The pits contain ore-refining impurities from uranium ore concentrates that were digested with nitric acid. The accumulation of aqueous phase waste (chiefly rainwater in contact with the raffinate) creates groundwater hydrostatic mounding beneath the pits, and nitrate-rich water impacts very localized portions of the bedrock aquifer in the raffinate pits vicinity. Some of the wastes generated and disposed of as raffinate contained isotopes of thorium and radium. Therefore, groundwater samples from selected locations near the raffinate pits were analyzed for nitrate, thorium and radium isotopes, and total uranium.

Prior to construction of the chemical plant, the site was part of a Department of Army Ordnance Works complex developed for the production of the nitroaromatic compounds trinitrotoluene (TNT) and dinitrotoluene (DNT) for explosives. One of the first nitroaromatic production lines was located within what is now the chemical plant area perimeter. Wastes generated from the initial operation of these early production lines were disposed of in open earthen pits which released contaminated seepage to groundwater. Nitroaromatic compound products were transported through wooden pipe networks. Discrete locations at the chemical plant are known (from previous sampling) to be impacted with nitroaromatics. Those locations

which were previously determined to have detectable concentrations of nitroaromatics in groundwater were sampled and analyzed for these compounds in 1995.

Groundwater moves by both diffuse and discrete flow components under the chemical plant. In order to monitor the discrete flow component, Burgermeister Spring was monitored during 1995 for total uranium, nitroaromatic compounds, nitrate, sulfate, and geochemical parameters. The spring was sampled during high and base flow conditions to monitor the potential impacts to the spring recharge from surface water runoff in the vicinity of the chemical plant.

8.3.2.2 Scope. All monitoring wells (except those completed in the unweathered aquifer) were sampled annually and analyzed for total uranium. Monitoring wells around the raffinate pits and chemical plant buildings were also analyzed annually for Ra-226, Ra-228, Th-228, Th-230, Th-232, and nitrate. Nitroaromatics were analyzed in groundwater from locations that have historically shown detectable concentrations of these compounds.

Burgermeister Spring (SP-6301) was monitored quarterly for nitrate, sulfate, and geochemical constituents. The spring was monitored at low flow to measure the groundwater component of spring discharge. It was sampled semiannually at high flow for uranium, nitrate, and sulfate to evaluate the differences between low flow and high flow. Nitroaromatic compounds were analyzed semiannually at low flow only to monitor the groundwater component nitroaromatic impacts.

8.3.3 Chemical Plant and Raffinate Pit Monitoring Results

8.3.3.1 Groundwater Monitoring Wells. In 1995, the measured concentrations for uranium, nitrate, sulfate, and nitroaromatic compounds generally remained within historical ranges at all monitoring wells and springs in the chemical plant area. Although new highs and lows were measured at some locations, these values generally differed from the mean by less than two standard deviations and typically reflected normal variation in the local aquifer system rather than significant changes in groundwater conditions.

Data for all parameters analyzed during the 1995 monitoring period are presented in the *Quarterly Environmental Data Summaries*. The monitoring data for contaminants of concern

(uranium, radiological parameters, nitrate, sulfate, and nitroaromatics) are summarized and compared with background levels and water quality standards in the following paragraphs. Data values are presented as reported by the analytical laboratories. Comparisons to drinking water standards are not intended to imply that groundwater from WSSRAP monitoring wells must be in compliance with drinking water standards.

Radiochemical Parameters. Total uranium, which is measured at all monitoring wells, continues to impact groundwater near the raffinate pits. In 1995, groundwater from 13 monitoring well locations exceeded the average background level of 2.9 pCi/l (0.11 Bq/l) as calculated by the USGS (Ref. 37). These values can be found in Table 8-3. Of these, only three locations exceeded or equaled the proposed MCL of 20 μg/l (13.6 pCi/l). New highs for uranium were recorded during 1995 at MW-2017 (15.2 pCi/l), MW-3023 (12.8 pCi/l) and MW-4012 (5.0 pCi/l). The MW-2017 uranium values have steadily increased at this location during the last three years. Uranium values in a newly installed well (MW-4024) suggest the uranium plume extends farther east off site than previously identified. Uranium levels at this location (southeast of the site entrance across State Route 94) exceeded the MCL value of 13.6 pCi/l (0.5 Bq/l).

The other radiological parameters (Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta) that are measured annually in the raffinate pit wells (MW-3000 series and MW-2044) were below the MCL values with one exception, the MW-3026 location which monitors groundwater along the southwestern perimeter of Raffinate Pit 4. These results can be found in Table 8-4.

Nitrate and Sulfate. Nitrate and sulfate were measured at all monitoring wells in the chemical plant area in 1995 and exceeded the reference levels at some locations. Average nitrate levels exceeded the calculated background value (1.6 mg/l) at 24 locations. The drinking water standard (10 mg/l) was exceeded at 15 of those locations (Table 8-5). Average sulfate levels exceeded background (32 mg/l) at 25 locations; three of these were above the secondary water quality standard (250 mg/l) (Table 8-6).

Trend analysis, which was conducted for the 1993 annual *Site Environmental Report* (Ref. 9) detected upward nitrate trends in three monitoring wells. One of these wells, MW-4011, continued to display these increases in 1995. Upward nitrate and sulfate trends were detected

TABLE 8-3 Annual Averages for Total Uranium (pCi/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE (pCi/l)	LOCATION	AVERAGE (pCi/l)	LOCATION	AVERAGE (pCi/l)
MW-2017	13.60	MW-2032	4.38	MW-2039	2.94
MW-2030	11.75	MW-3023	9.18	MW-4010	2.92
MW-3003	15.53	MW-3026	3.00	MW-4022	9.67
MW-4011	3.07	MW-4012	3.86	MW-4024	31.85
MW-4020	11.52				

Note 1: Background uranium concentrations equals 2.9 pCi/l.
Note 2: 1 pCi/l = 0.037 Bq/l.

Table 8-4 Radiological Isotope Results (pCi/l) at the Weldon Spring Chemical Plant

LOCATION	RA-226 (pCi/l)	RA-228 (pCi/l)	TH-228 (pCi/l)	TH-230 (pCi/l)	TH-232 (pCi/l)	GROSS ALPHA (pCi/l)	GROSS BETA (pCi/l)
MW-2044	(0.2)	(0.9)	<1.0	<1.0	<1.0	2.1	4.2
MW-3003	(0.565)	(0.392)	(0.174)	0.871	<0.183	17.9	28.4
MW-3006	(0.346)	1.89	(0.126)	0.252	(0.0314)	(0.445)	<2.73
MW-3019	1.07	(0.391)	(0.227)	0.422	(0.0972)	2.56	3.47
MW-3023	<0.656	(0.660)	(0.145)	0.169	<0.178	18.2	18.2
MW-3024	(0.682)	(0.369)	(0.0683)	(0.205)	(0.0272)	(9.60)	24.4
MW-3025	(0.479)	<1.68	(0.0411)	(0.473)	0.0616	<14.2	21.3
MW-3026	1.95	(0.425)	0.991	1.03	1.14	33.9	29.5
MW-3027	1.89	2.39	(0.196)	0.648	0.0784	7.62	9.49

Note 1: Results in parentheses were less than the quantification limit.

TABLE 8-5 Annual Averages for Nitrate (mg/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	LOCATION	AVERAGE	LOCATION	AVERAGE
MW-2001*	46.0	MW-2002*	115	MW-2003*	295.0
MW-2005*	63	MW-2006	4.80	MW-2011	4.13
MW-2014	1.75	MW-2032*	42.5	MW-2034	2.45
MW-3003*	370.0	MW-3023*	130	MW-3024*	408
MW-3025*	414.5	MW-3026*	202.0	MW-3027*	58.0
MW-4001*	32.0	MW-4002	3.00	MW-4006	12.5
MW-4011*	165	MW-4013*	85	MW-4014	3.0
MW-4015	4.1	MW-4018	2.65	MW-4023	2.45

Note 1: Background Nitrate Concentrations equals 1.6 mg/l
* Exceeded the nitrate drinking water quality standard of 10 mg/l at least once during 1995.

TABLE 8-6 Annual Averages for Sulfate (mg/l) Above Background at the Weldon Spring Chemical Plant

LOCATION	AVERAGE	LOCATION	AVERAGE	LOCATION	AVERAGE
MW-2002	120	MW-2003	100	MW-2006	9.2
MW-2012	58.0	MW-2014	38.0	MW-2010	41.0
MW-2017*	1120	MW-2028	125.0	MW-2015	132
MW-2032	54	MW-2033	42.0	MW-2030	50.0
MW-2044	127	MW-3003	135	MW-2034*	320
MW-3024	80.0	MW-3025	48.85	MW-3023*	250
MW-4011	83	MW-4012	36	MW-4001	65.0
MW-4020	150	MW-4021*	260	MW-4013	56
				MW-4023	93

Note 1: Background sulfate concentration equals 32 mg/l
* Exceeded the sulfate secondary drinking water quality standard of 250 mg/l at least once during 1995.

in MW-4011. Trend analyses for 1994 to 1995 data are presented in Section 8.3.4 of this document.

MW-2034 had shown a steady increase in nitrate concentrations and a decrease in sulfate concentrations over the previous 2 years, but has stabilized for 1995. Nitrate levels have not exceeded the drinking water standards, but sulfate continues to exceed the secondary drinking water standard. These values may reflect shifts in the uppermost groundwater flow patterns, possibly influenced by changes in groundwater recharge due to changes in surface water infiltration, or to remedial action activities (pumping raffinate pits, lining around the TSA). MW-2017, located approximately 5.2 m (17 ft) northwest of MW-2034, did not show nitrate increases for the previous two years, but did have noticable increases in both nitrate and sulfate for 1995.

Nitroaromatic Compounds. Nitroaromatic compounds, which are not naturally occurring compounds, were detected in 28 monitoring wells (Table 8-7). New highs were recorded at MW-2002 for 2,6-DNT and at MW-2030 for 2,4,6-TNT. The high at MW-2002 was within the normal range of variation for this location; however, the increases at MW-2030 appear to be part of an increasing trend. Although new highs were not recorded, 2,6-DNT levels have also been elevated at this location. Levels rose from an average of 4.0 μg/l in 1993 to 15.0 μg/l in 1994 and remained elevated at 9.40 μg/l for 1995. The drinking water standard for 2,4-DNT of 0.11 μg/l was exceeded in 12 locations at the chemical plant (see Table 8-7), all of which are in the northern one-third of the site or along the western perimeter.

Trend analysis conducted for the 1993 annual *Site Environmental Report* (Ref. 9) detected upward nitroaromatic trends at six monitoring wells: MW-2001 (TNT and 2,4-DNT), MW-2006 (2,4-DNT), MW-2008 (2,4-DNT), MW-2014 (TNT), MW-3023 (TNT), and MW-4015 (TNB). With the exception of MW-3023, which decreased slightly during 1994, all of these wells maintained 1993 nitroaromatic levels during 1994. With one exception, wells in which downward trends were detected at a number of locations have remained stable or continued to decrease during 1994. The only exception is MW-2013. Groundwater from this location displayed steep, decreasing trends for all nitroaromatic compounds until 1994. During 1994, increasing levels of TNB and 2,6-DNT were detected in groundwater from this well. In addition to the nitroaromatic compounds, sulfate, calcium, magnesium, and alkalinity also increased at this location. Although the source of this change is not known, construction activities in this

TABLE 8-7 Annual 1995 Averages for Detectable Concentrations of Nitroaromatic Compounds (µg/l) at the Weldon Spring Chemical Plant

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-2001	.056	<0.090	<0.030	0.12	0.055	<0.040
MW-2002	<0.030	<0.090	<0.030	0.062	0.39	<0.030
MW-2003	<0.030	<0.090	<0.030	0.014	0.43	<0.030
MW-2005	0.033	<0.090	<0.030	0.059	0.087	<0.040
MW-2006	3.06	<0.090	<0.030	0.080	0.65	0.03
MW-2010	0.14	<0.090	0.31	0.091	0.62	<0.040
MW-2011	0.34	<0.090	<0.030	0.19	1.5	0.032
MW-2012	1.30	<0.090	0.46	0.089	0.55	<0.040
MW-2013	5.50	<0.090	0.69	0.330	4.00	<0.040
MW-2014	2.5	<0.090	0.042	0.160	0.490	<0.040
MW-2030	7.80	<0.18	24.0	0.205	9.40	<0.040
MW-2032	3.60	<0.018	6.45	0.450	3.65	<0.040
MW-2033	4.15	<0.090	1.15	0.495	4.20	<0.040
MW-3003	<0.030	<0.090	<0.030	0.46	0.23	<0.040
MW-3023	<0.030	<0.090	<0.080	5.05	4.60	<0.040
MW-3024	<0.030	<0.090	<0.030	0.127	0.44	<0.040
MW-3025	<0.030	<0.090	<0.030	0.082	0.27	<0.040
MW-3026	0.078	<0.090	<0.030	0.068	0.046	<0.040
MW-3027	0.074	<0.090	<0.030	0.052	0.029	<0.040
MW-4001	37.0	<0.090	1.7	0.860	3.05	<0.06
MW-4002	0.04	<0.090	0.91	0.080	0.15	<0.040
MW-4006	14.5	<0.090	<0.030	0.140	2.8	<0.040
MW-4011	<0.030	<0.090	<0.030	<0.030	0.064	<0.040
MW-4013	25.5	<0.090	0.043	0.068	0.70	<0.040
MW-4014	0.060	<0.090	<0.030	0.020	0.05	<0.040

TABLE 8-7 Annual 1995 Averages for Detectable Concentrations of Nitroaromatic Compounds (μg/l) at the Weldon Spring Chemical Plant (Continued)

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-4015	1.65	<0.090	<0.030	0.165	0.97	<0.040

area may have disturbed surface soils and modified infiltration pathways, thus exposing previously covered nitroaromatic contaminated areas to contaminant leaching into groundwater. The 1995 analytical data indicate that increases in contamination have stabilized. Nitroaromatic trend analyses for the chemical plant 1994-1995 data are presented in Section 8.3.4 of this document.

Groundwater Overview. With few exceptions, contaminant levels remained within historic ranges at the monitoring wells sampled under the environmental monitoring program. Because contaminant levels have displayed only minor variability over the historic monitoring period, trend analysis is not conducted annually for the chemical plant monitoring wells. Uranium, sulfate, and nitrate contamination continue to be concentrated in the area surrounding the raffinate pits with a small area of elevated uranium and sulfate located near the eastern boundary of the site. Pockets of nitroaromatic contaminated groundwater continue to be present in the vicinity of Frog Pond, along the northern perimeter of the site, near Raffinate Pit 4, and west of the raffinate pits on the Weldon Spring Ordnance Works property.

Contamination is primarily confined to groundwater in the shallow, weathered portion of the Burlington Keokuk limestone; however, contaminants have been observed in the deeper, unweathered portion of the aquifer in two retrofited wells (MW-3024 and MW-3026) near the raffinate pits. Conditions at shallow and deep private water wells monitored by the Missouri Department of Health remained unchanged during 1995 and continue to indicate vicinity domestic wells are not impacted by site-derived contaminants.

8.3.3.2 Springs. Burgermeister Spring was the only location (SP-6301) monitored for the 1995 environmental monitoring program. This location is a perennial spring and is a localized emergence of groundwater impacted by a recognizable contribution of contaminants

from the chemical plant throughout the year, with the highest concentrations of contaminants occurring during base flow stages. During high flow conditions, surface water recharge along the path of the subsurface flow mixes with contaminated flow from the site, and the concentrations are effectively lowered. The spring was monitored during both high and base stages during 1995.

Uranium, nitrate, and nitroaromatics were within expected (historic) ranges during 1995. The mean concentrations for nitrate and sulfate during base flow are 26.0 mg/l and 39.0 mg/l, respectively. These concentrations for high stage flow are 23.9 mg/l and 34.7 mg/l, respectively. These results indicate that groundwater is a more significant contributor to the spring discharge during base flow. The concentrations for these parameters are lower during high flow due to surface water contribution. Base flow concentrations for nitrate ranged between 5.1 mg/l and 46.6 mg/l. Base flow sulfate ranged between 33.0 mg/l and 43 mg/l for 1995.

Uranium concentrations analyzed in samples from the spring were between 47.4 pCi/l (1.75 Bq/l) and 91.2 pCi/l (3.37 Bq/l), with a mean value of 63.05 pCi/l (2.33 Bq/l). These values are within the expected range for uranium.

Nitroaromatics were analyzed in samples from base stage flow only. The concentrations of detected nitroaromatic compounds are within historic ranges. These compounds include 2,4,6-trinitrotolue (0.19 μg/l), 2,4-dinitrotoluene (0.05 μg/l) and 2,6-dinitrotoluene (0.27 μg/l).

Monitoring of Burgermeister Spring will continue to determine whether remediation activities across the northern half of the chemical plant impact the local groundwater quality for the duration of the project.

8.3.4 Chemical Plant Trend Analyses

Statistical Methods

Statistical tests for time-dependent trends were performed on historical and current groundwater data representing select groundwater wells. The constituents and locations that were selected for trending included total uranium, nitroaromatic compounds, and nitrate in samples from the chemical plant wells. Trend analyses were performed individually for each

monitoring well and contaminant. The specific locations, parameters, and time periods selected for trending analyses are presented in Tables 8-8 through 8-10. The selected locations, parameters, and time periods were based on the historical site environmental remediation activities, historical groundwater monitoring data, and knowledge of the site processes. The number of observations and number of data reported as below the detection limit for each data set are also shown on the summary tables.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test. This program was selected because it can easily facilitate missing data and does not require the data to conform to a particular distribution. The nonparametric method is valid for scenarios in which there are a high number of non-detect data points. Data reported as trace concentrations or less than the detection limit can be used by assigning them a common value that is smaller that the smallest measured value in the data set (i.e., one-half the specified quantitation limit). This approach is valid since only the relative magnitudes of the data, rather than their measured values, are used in the method. The TREND program was also used in past analyses of the site groundwater data. Thus, use of the TREND program offered the advantage of maintaining continuity in the analysis methodology. The two-tailed version of the Mann-Kendall test was employed to detect either an upward or downward trend for each data set. In this approach a test statistic, Z, is calculated. A positive value of Z indicates an upward trend. Likewise, a negative value of Z indicates a downward trend. The alpha value selected for testing was 0.05. In the two-tailed test at the 0.05 alpha level of significance, the null hypothesis of "no trend" was rejected if the absolute value of the Z statistic was greater than $Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ was obtained from a cumulative normal distribution table. Thus, the absolute value of the TREND output statistic, Z was compared to the tabled $Z_{.975}$ value

TABLE 8-8 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2001	West of Ash Pond	2,4-DNT	11	3	0	0	U	(a)	0.02	--	0.01, 0.02	--
		2,6-DNT	11	3	0	0	S	(a)	(b)	--	-0.01, 0.01	--
MW2002	West of Ash Pond	2,4-DNT	11	3	0	0	S	(a)	0.01	--	-0.00, 0.01	--
		2,6-DNT	11	3	0	0	S	(a)	0.05	--	-0.05, 0.13	--
MW2005	North Dump Area	2,4-DNT	9	3	1	0	S	(a)	-0.01	--	-0.01, 0.01	--
		2,6-DNT	9	3	1	0	S	(a)	-0.01	--	-0.03, 0.01	--
MW2006	Northwest of Frog Pond	2,4-DNT	10	4	3	1	S	S	0.02	-0.09	-0.02, 0.07	N too small
		2,6-DNT	10	4	0	0	S	S	-0.20	-0.80	-0.67, 0.04	N too small
MW2010	West of Frog Pond	2,4-DNT	10	4	1	0	S	S	0.01	0.01	-0.00, 0.02	N too small
		2,6-DNT	10	4	0	0	D	S	-0.12	0.29	-0.21, -0.06	N too small
		2,4,6-TNT	10	4	1	0	S	S	-0.01	-0.03	-0.06, 0.06	N too small
MW2012	Southwest of Frog Pond	2,4-DNT	10	4	1	0	S	S	-0.01	-0.02	-0.21, 0.01	N too small
		2,6-DNT	10	4	1	0	D	S	-0.10	-0.56	-1.49, -0.06	N too small
		2,4,6-TNT	10	4	1	0	D	S	-0.08	-0.07	0.20, -0.01	N too small

TABLE 8-8 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION[a]	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2013	South of Frog Pond	2,4-DNT	10	4	0	0	D	S	-0.04	0.09	-0.16, 0.00	N too small
		2,6-DNT	10	4	0	0	D	S	-6.80	-0.50	-8.96, -2.41	N too small
		2,4,6-TNT	10[3]	4	0	0	D	S	-0.27	0.21	-0.47, -0.10	N too small
MW2014	Southeast of Frog Pond	2,4-DNT	11	4	1	0	U	S	0.02	-0.03	0.01, 0.03	N too small
		2,6-DNT	12	4	0	0	D	S	-0.19	0.01	-0.27, -0.07	N too small
MW2030	North Side of Chem Plant	2,4-DNT	12	6	0	0	S	S	0.02	-0.10	-0.03, 0.04	N too small, 0.02
		2,6-DNT	12	6	0	0	S	S	-1.40	-4.00	-5.39, -2.00	N too small, 3.80
		2,4,6-TNT	12	6	0	0	U	S	4.95	1.00	2.75, 6.00	N too small, 8.64
MW2032	MSA/CMSA Area	2,4-DNT	10	2	0	0	S	(a)	0.02	--	-0.01, 0.04	--
		2,6-DNT	10	3	0	0	S	(a)	-0.15	--	-0.60, 0.20	--
		2,4,6-TNT	10	3	0	0	S	(a)	0.96	--	-0.42, 3.96	--

TABLE 8-8 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2033	Southeast Frog Pond	2,4-DNT	13	5	0	0	S	S	0.01	0.26	-0.06, 0.01	N too small, 0.07
		2,6-DNT	13	5	0	0	D	S	-2.85	2.40	-4.78, -0.80	N too small, 0.50
		2,4,6-TNT	13	5	0	0	S	S	-1.00	0.35	-0.72, 0.30	N too small, 0.12
MW2037	West TSA-South Raffinate Pit 4	2,4-DNT	9	9	0	0	S	D	(b)	-0.09	-0.10, 0.05	-0.18, -0.04
		2,6-DNT	9	9	0	0	S	S	-0.02	-0.02	-0.04, 0.00	-0.04, 0.01
		2,4,6-TNT	9	9	14	9	S	(c)	(b)	--	0.00, 0.00	--
MW2038	South Raffinate Pit 3	2,4-DNT	9	9	0	0	S	D	0.10	-0.20	0.00, 0.30	-0.30, -0.05
		2,6-DNT	9	9	0	0	U	D	0.03	-0.04	0.00, 0.06	-0.07, -0.01
		2,4,6-TNT	9	9	9	9	(c)	(c)	--	--	--	--
MW3003	North Raffinate Pit 4	2,4-DNT	9	3	0	0	S	(a)	(b)	--	-0.03, 0.02	--
		2,6-DNT	9	3	0	0	S	(a)	(b)	--	-0.04, 0.03	--
MW3023	North Raffinate Pit 4	2,4-DNT	13	5	0	0	S	S	-1.00	-0.10	-1.50, 0.19	N too small
		2,6-DNT	13	5	0	0	D	S	-1.64	0.30	-2.10, -0.82	N too small
MW3025	East Raffinate Pit 3	2,4-DNT	5	8	0	0	S	S	0.03	-0.01	N too small	-0.04, 0.02

TABLE 8-8 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
		2,6-DNT	5	8	0	0	S	S	0.09	-0.01	N too small	-0.08, 0.07
MW3027	SW Raffinate Pit 4	2,4-DNT	5	8	0	0	S	S	0.03	0.01	N too small	-0.01, 0.02
		2,6-DNT	5	8	0	0	S	S	0.02	0.02	N too small	-0.02, 0.01
MW4001	West Perimeter, Raffinate Pit 4	2,4-DNT	13	4	1	0	D	S	-1.83	-0.04	-2.89, 1.34	N too small
		2,6-DNT	13	4	1	0	D	S	-0.73	-0.65	-1.50, -0.09	N too small
		2,4,6-TNT	13	4	2	0	S	S	0.07	-0.10	-0.60, 0.25	N too small, 0.00
MW4002	West Perimeter, Raffinate Pit 4	2,4-DNT	12	4	5	2	S	(a)	0.00	--	-0.03, 0.01	--
		2,6-DNT	12	4	1	0	S	S	0.01	0.06	-0.28, 0.18	N too small
		2,4,6-TNT	12	4	1	1	S	S	0.13	0.65	-0.17, 0.50	N too small
MW4006	West Perimeter, Raffinate Pit 4	2,4-DNT	12	4	2	0	S	S	-0.03	0.02	-0.08, 0.01	N too small
		2,6-DNT	12	4	1	0	D	S	-0.78	-0.05	-1.42, -0.40	N too small
MW4011 **	West Perimeter Ash Pond	2,4-DNT	9	3	9	3	(c)	(a)	--	--	--	--
		2,6-DNT	9	3	8	0	(c)	(a)	--	--	--	--

TABLE 8-8 Chemical Plant Groundwater Wells Nitroaromatics Trend Analysis Summary (Continued)

WELL ID	LOCATION*	COMPOUND	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (µg/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (µg/l/yr)	
			1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW4013	North-Northwest Perimeter	2,4-DNT	11	3	0	0	S	(a)	0.01	--	-0.01, 0.01	--
		2,6-DNT	11	3	0	0	S	(a)	-0.25	--	-0.59, 0.01	--
		2,4,6-TNT	11	3	0	0	S	(a)	0.00	--	-0.01, 0.00	--
MW4014	North Perimeter	2,4-DNT	9	3	8	1	(c)	(a)	0.00	--	0.00, 0.00	--
		2,6-DNT	9	3	0	1	U	(a)	0.02	--	0.00, 0.03	--
MW4015	North-Northeast Perimeter	2,4-DNT	10	4	0	0	S	S	-0.01	0.04	-0.09, 0.03	N too small
		2,6-DNT	10	4	0	0	S	S	-0.19	0.12	-0.45, 0.03	N too small
MW4023	South-Southeast Perimeter	2,4-DNT	8	2	0	0	S	(a)	-0.01	--	-0.03, 0.01	--
		2,6-DNT	8	2	0	0	S	(a)	-0.01	--	-0.02, -0.00	--

D Downward
S Stationary
U Upward
(a) Location not selected for trending
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* All wells are completed in the weathered upper zone of the Burlington-Keokuk limestone, with the exception of MW4011
** MW4011 is completed in the unweathered zone of the Burlington-Keokuk limestone.

TABLE 8-9 Chemical Plant Groundwater Wells Total Uranium Trend Analysis Summary

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2003	North of Raffinate Pit 4	11	3	2	0	U	(a)	0.58	--	0.10, 0.99	--
MW2004	North Dump Area	9	1	1	0	S	(a)	0.11	--	-0.04, 0.28	--
MW2015	Center of Chemical Plant	9	3	1	0	S	(a)	0.37	--	-0.85, 0.60	--
MW2017	East Side Chemical Plant	10	4	0	0	U	S	1.85	1.00	0.80, 3.36	N too small
MW2018	South Side Chemical Plant	10	3	1	0	U	(a)	0.32	--	0.07, 0.61	--
MW2030	North Side Chemical Plant	14	6	0	0	S	S	1.50	-0.65	-0.34, 3.20	N too small, 0.71
MW2032	MSA/CMSA Area	11	3	1	0	S	(a)	0.10	--	-1.49, 1.36	--
MW2033	Southeast Frog Pond	14	6	2	0	S	S	0.10	-0.12	-0.16, 0.32	N too small, 0.66
MW2039	South Raffinate Pits 1 & 2	9	8	0	0	S	S	0.22	-0.15	-0.05, 1.02	-1.07, 2.92
MW3003	North Raffinate Pit 4	14	7	0	0	D	S	-2.00	0.46	-3.50, -0.16	-5.24, 6.28
MW3019	South of all Raffinate Pits	9	4	1	0	S	(a)	0.30	--	-2.41, 0.44	--
MW3023	North Raffinate Pit 4	13	6	0	0	S	S	0.20	0.63	-0.88, 0.93	N too small, 4.61
MW3025	East Raffinate Pit 3	4	7	0	0	S	D	0.16	-0.29	N too small	-1.25, -0.06
MW3027	Southwest Raffinate Pit 4	5	8	0	0	S	S	0.58	-0.48	N too small	-33.53, 0.02

TABLE 8-9 Chemical Plant Groundwater Wells Total Uranium Trend Analysis Summary (Continued)

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW4001	West Perimeter, Raffinate Pit 4	9	4	1	0	S	S	-0.18	0.01	-0.70, 0.10	N too small
MW4002	West Perimeter, Raffinate Pit 4	9	3	4	0	S	(a)	0.02	--	-0.13, 0.44	--
MW4005	Southwest Perimeter	9	4	1	0	S	S	-0.41	0.04	-4.08, 0.29	N too small
MW4013	North-Northwest Perimeter	10	4	2	1	S	(a)	0.01	--	-0.24, 0.41	--
MW4015	North-Northeast Perimeter	10	4	3	1	S	(a)	-0.09	--	-0.37, 0.34	--
MW4018	East-Northeast Perimeter	9	3	4	0	S	(a)	-0.09	--	-0.40, 0.23	--
MW4019	South Perimeter	10	4	0	0	S	S	-0.16	0.12	-0.89, 0.16	N too small
MW4020	East-Southeast Perimeter	14	8	0	0	D	S	-1.20	-1.19	-2.86, 0.00	-12.09, 1.94
MW4021	Southeast Perimeter	12	4	0	0	S	S	-0.85	-1.38	-2.35, 0.45	N too small
MW4023	South-Southeast Perimeter	9	4	2	0	S	S	0.85	-0.55	-0.10, 0.50	N too small

D Downward
S Stationary
U Upward
(a) Location not selected for trending
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* All wells are completed in the weathered upper zone of the Burlington-Keokuk limestone.

TABLE 8-10 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW2001	West of Ash Pond	13	4	0	0	U	S	6.02	8.75	3.75, 8.77	N too small
MW2002	West of Ash Pond	14	4	0	0	S	S	-21.667	-60.00	-96.70, 12.04	N too small
MW2003	North of Raffinate Pit 4	14	4	0	0	S	S	23.57	66.50	-48.04, 110.63	N too small
MW2005	North Dump Area	10	4	0	0	S	S	-1.650	-10.00	-34.69, 5.95	N too small
MW2012	Southwest of Frog Pond	9	3	0	0	S	(a)	-0.095	--	-0.33, 0.13	--
MW2032	MSA/CMSA Area	11	3	0	0	S	(a)	-5.283	--	-23.62, 14.61	--
MW2037	West TSA-South Raffinate Pit 4	9	9	0	0	S	D	-95.500	-29.50	-236.02, 31.17	-270.69, -5.81
MW2038	South Raffinate Pit 3	9	9	0	0	D	S	-516.000	-76.00	-931.57, -372.84	-140.19, 380.00
MW2039	South Raffinate Pits 1 & 2	9	8	0	0	S	S	-12.200	-12.50	-40.04, 12.79	-25.49, 1.46
MW3003	North Raffinate Pit 4	12	4	0	0	S	S	-1.750	71.50	-69.29, 71.71	N too small
MW3023	North Raffinate Pit 4	14	4	0	0	D	S	-38.000	-99.00	-67.40, -14.65	N too small
MW3025	East Raffinate Pit 3	5	8	0	0	S	S	-309.00	-13.00	N too small	-209.93, 113.22
MW3027	Southwest Raffinate Pit 4	5	8	0	0	S	S	-19.000	-2.75	N too small	-15.40, 3.25
MW4001	West Perimeter, Raffinate Pit 4	10	4	1	0	U	S	3.88	-8.25	-1.34, 6.34	N too small
MW4002	West Perimeter, Raffinate Pit 4	9	3	0	0	S	(a)	0.73	--	-0.35, 3.22	--

TABLE 8-10 Chemical Plant Groundwater Wells Nitrate Trend Analysis Summary (Continued)

WELL ID	LOCATION*	NO. OF OBSERVATIONS (N)		NO. OF NON-DETECT DATA		TREND DIRECTION		SLOPE (pCi/l/yr)		95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)	
		1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995	1991-1994	1994-1995
MW4006	West Perimeter, Raffinate Pit 4	9	3	0	0	U	(a)	1.03	--	0.07, 1.80	--
MW4011 **	West Perimeter Ash Pond	10	4	0	0	U	S	26.06	34.50	15.17, 43.15	N too small
MW4013	North-Northwest Perimeter	11	3	0	0	S	(a)	-0.417	--	-33.37, 20.47	--
MW4014	North Perimeter	9	3	0	0	S	(a)	1.11	--	-0.17, 2.92	--
MW4015	North-Northeast Perimeter	10	4	0	0	S	S	0.90	0.90	-0.17, 0.98	N too small
MW4018	East-Northeast Perimeter	9	3	0	0	S	(a)	-0.065	--	-3.45, 0.64	--
MW4020	East-Southeast Perimeter	9	4	4	3	S	(a)	0.01	--	-0.07, 0.26	--
MW4023	South-Southeast Perimeter	10	3	0	0	S	(a)	0.50	--	-0.47, 1.77	--

D Downward
S Stationary
U Upward
(a) Location not selected for trending
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* All wells are completed in the weathered upper zone of the Burlington-Keokuk limestone with the exception of MW-4011.
** MW4011 is completed in the unweathered zone of the Burlington-Keokuk limestone.

of 1.96. If the absolute value of the Z output statistic was greater than 1.96, then a significant trend was reported.

One-half the specified quantitation limit (on the date of analysis) was used in the trend analysis for all data reported as below the detection limit. The purpose of utilizing one-half the quantitation limit for non-detect data was to minimize the potential bias of the data. However, a consequence of this approach may be that in some instances the results may have been impacted by quantitation limits changing over time. The affect of varying quantitation limits is more likely to impact the trending analysis in instances where a large number of non-detect data are present within a given time series. The summary tables include the total number of data observations and the total number of non-detect data points for each data set so that this factor may be considered.

Graphs presenting the contaminant concentration versus time for each contaminant per trending location were developed. These graphs were utilized to help identify suspect data outliers for each trending analysis. No statistical tests for suspect outliers were conducted. Data which were suspect were flagged and rechecked for potential data transcription errors, etc. No obvious errors were identified. Thus, all data were included in the trending analyses regardless of whether they were suspect outliers unless they were qualified by the WSSRAP QA/QC data review process.

In general, data collected between the years 1991 and 1994 were filtered using a .45-micron filter. Data collected in 1995 and 1996 were collected as non-filtered samples. In order to maintain continuity during the trending analyses, non-filtered data obtained between the years 1991 and 1994 were removed if both filtered and non-filtered data were reported for the same period of time. Similarly, filtered data collected in 1995 were also removed if both filtered and non-filtered data were reported for the same time periods. However, some of the data points from 1992 used in the trend analysis represented non-filtered samples (filtered samples were not collected for these periods). Subsequent trend analyses were conducted with the non-filtered data collected during 1992 was removed to determine if the non-filtered data had any affect on the trend direction for data between the years 1991 and 1994. Overall, filtered and non-filtered sampling results appeared to be very similar in concentration. This is demonstrated by comparing filtered versus non-filtered data for the same time period. The graphs generated presenting the contaminant concentration versus time indicate that the

difference between filtered and non-filtered concentrations for the sample time is relatively minimal.

In order to maintain sufficient power of the test, the analysis was limited to data sets with four or more data points. Therefore, if fewer than four detected concentrations were present in a given time series for a contaminant, the data set was not analyzed. These data sets are designated as "(a)" and "(c)" in the summary table.

The linear slope of the trend was estimated for all data sets in which a significant upward or downward trend was identified. The slope was estimated using a nonparametric procedure included in the computer code for the TREND program.

The estimates of the trend slope for all data sets with identified trends are provided in Tables 8-8 through 8-10. A $100(1-\alpha)\%$ two-sided confidence interval about the true slope was also obtained by the nonparametric technique. The upper and lower 95% confidence limit estimates of the slope are included in the far right columns of the summary tables.

Trend analyses are intended to statistically indicate the presence of an upward or downward trend in contaminant concentration and should not be used as predicting future concentrations. The trend analyses should be used to identify site locations which may require close scrutiny during future monitoring.

Nitroaromatic Compounds

No upward trends at the chemical plant for nitroaromatic compounds were suggested by the trend analysis for 1994-1995 data. Locations for which upward trends were detected using 1991-1994 data (west of Ash Pond, south of Raffinate Pit 3, and along the northern perimeter of the site) have stabilized. A summary of nitroaromatic trend analysis for the chemical plant is found in Table 8-8.

Total Uranium

Groundwater uranium analytical results were trended at locations representing all areas of the chemical plant. No upward trends were detected. The uranium trend analysis is summarized in Table 8-9.

Nitrate

Nitrate concentrations were trended at locations along site perimeters and in the immediate vicinity of the raffinate pits. Locations that previously (1991-1994) showed upward trends have stabilized. These stabilized locations include the raffinate pit monitoring wells. No upward trends were detected. The nitrate trend analyses are summarized in Table 8-10.

8.4 Weldon Spring Quarry

8.4.1 Hydrogeology

The geology of the quarry area is separated into three units; upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 2). Three Ordovician-age formations comprise the bedrock at the quarry: The Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone. The alluvium along the Missouri River consists of clays, silts, sands, and gravels above the bedrock. The alluvium thickness increases with distance from the bluff towards the river where the maximum thickness is approximately 31 m (100 ft). The alluvium is truncated at the erosional contact with the Ordovician bedrock bluff (Kimmswick, Decorah, and Plattin formations) which also composes the rim wall of the quarry. The bedrock unit underlying the alluvial materials is the Decorah Group. Primary sediments between the bluff and the Femme Osage Slough are inorganic and organic intermixed and interlayered clays, silts, and sands with some organics.

The uppermost groundwater flow systems at the quarry are composed of alluvial and bedrock aquifers. The alluvial aquifer is predominantly controlled by recharge from the Missouri River and the bedrock aquifer is chiefly recharged by precipitation and overland runoff.

At the quarry, 17 monitoring wells are screened within either the Kimmswick-Decorah (upper unit) or Plattin Formations (lower unit) to monitor contaminants near the quarry within the bedrock (Figure 8-4). Twelve monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. Three other monitoring wells are located south of the quarry within the Plattin Limestone to assess vertical contaminant migration. Two monitoring wells, one in the Kimmswick-Decorah Formation and one in the Plattin Formation, were installed north of the quarry in 1995 to monitor upgradient groundwater quality. These wells will be used for background data when sufficient data are available.

There are also 36 monitoring wells screened in the alluvium at the quarry and to the Missouri River. The wells west of the quarry monitor the uppermost water bearing unit below the quarry water treatment plant equalization basin and effluent ponds. The alluvium monitoring wells north of the Femme Osage Slough monitor contaminant migration south of the quarry, while those south of the slough monitor for possible migration of contaminants toward the well field. The St. Charles County monitoring wells, the RMW series wells, are designed to provide an early warning of contaminant migration toward the county production well field. The county production wells are monitored to verify the quality of the municipal well field water supply. The wells located in the Missouri River flood plain were capped with water-tight, compression-fit caps prior to and during the floodwater inudation event of May 1995 to September 1995.

Monitoring wells MW-1042 (Plattin) and MW-1043 (Decorah) provide upgradient groundwater quality data for the central portion of the quarry. These wells were installed in 1995 as part of the quarry residuals operable unit. Monitoring wells MW-1034 (Kimmswick-Decorah) and MW-1035 (alluvium) are upgradient of the southwestern portion of the quarry. These upgradient wells provide an assessment of groundwater quality in these materials and provide background data. In 1992, eight groundwater monitoring wells were installed in the Darst Bottom area approximately 1.6 km (1 mi) southwest of the St. Charles County well field by the U.S. Geological Survey (USGS) to study the upgradient characteristics of the Missouri

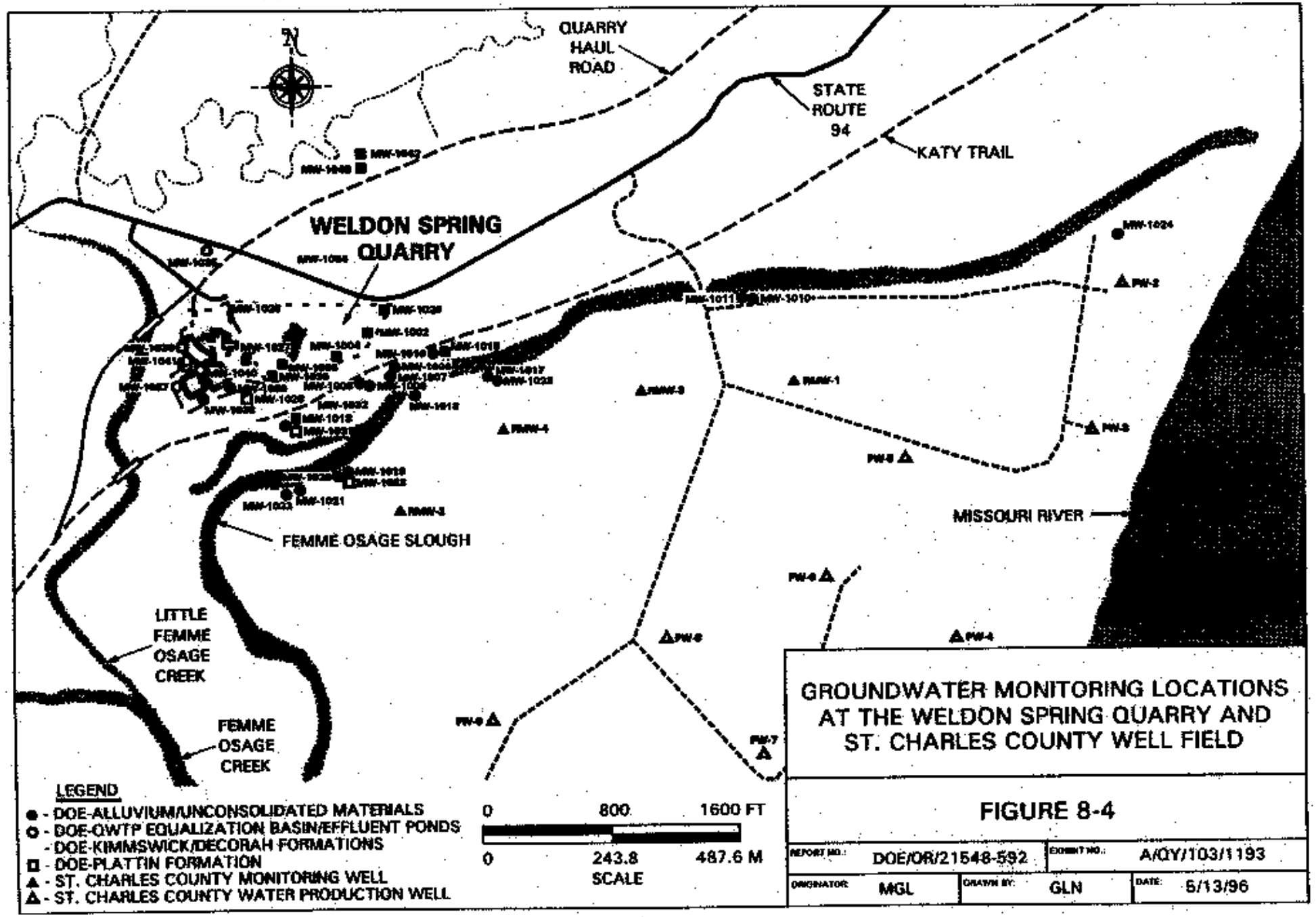
TABLE 8-11 Mean Background Values for Quarry Groundwater Monitoring Locations

PARAMETER		KIMMSWICK/ DECORAH FORMATIONS[a]	ALLUVIAL/ UNCONSOLIDATED MATERIALS[b]	MISSOURI RIVER ALLUVIUM[c]
Total Uranium (pCi/l)	Mean	2.35	0.67	2.03
	95% C.I.*	-1.18; 5.88	-0.83; 2.16	-2.71; 6.78
Radium-226 (pCi/l)	Mean	0.18	0.50	1.41
	95% C.I.*	±0.78**	±0.77**	±1.71**
Radium-228 (pCi/l)	Mean	0.77	0.48	1.59
	95% C.I.*	±2.06**	±2.06**	±13.1**
Thorium-228 (pCi/l)	Mean	0.26	0.39	0.24
	95% C.I.*	±0.94**	±1.03**	±1.72**
Thorium-230 (pCi/l)	Mean	0.93	0.32	0.69
	95% C.I.*	±0.55**	±0.94**	±2.93**
Thorium-232 (pCi/l)	Mean	0.26	0.12	0.20
	95% C.I.*	±0.92**	±0.86**	±1.68**
Gross α (pCi/l)	Mean	6.75	1	1.54
	95% C.I.*	±6.85**	±3.5**	±16.6**
Gross ß (pCi/l)	Mean	5.77	5.9	3.0
	95% C.I.*	±5.06**	±2.5	±13.9**
Nitroaromatic Compounds	Mean	No detects	No detects	Not analyzed
Arsenic (μg/l)	Mean	1.38	1.53	4.08
	95% C.I.*	-0.94; 3.70	-0.99; 4.04	-1.29; 9.46
Barium (μg/l)	Mean	144.9	232.0	408.6
	95% C.I.*	110.0; 179.8	178.4; 285.6	137.1; 680.0
Nitrate (mg/l)	Mean	1.06	0.11	0.46
	95% C.I.*	-0.62; 2.73	-0.05; 0.26	-2.33; 3.24

TABLE 8-11 Mean Background Values for Quarry Groundwater Monitoring Locations (Continued)

PARAMETER		KIMMSWICK/ DECORAH FORMATIONS[a]	ALLUVIAL/ UNCONSOLIDATED MATERIALS[b]	MISSOURI RIVER ALLUVIUM[c]
Sulfate (mg/l)	Mean	82.3	38.8	37.1
	95% C.I.*	32.6; 132.0	23.1; 54.5	6.31; 68.0

(a) MW-1034 (DOE)
(b) MW-1035 (DOE)
(c) Darst Bottom Wells (USGS and DOE)
* 95% Confidence Interval about the mean
** Average radiological error



GROUNDWATER MONITORING LOCATIONS AT THE WELDON SPRING QUARRY AND ST. CHARLES COUNTY WELL FIELD

FIGURE 8-4

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/OY/103/1193		
ORIGINATOR:	MGL	DRAWN BY:	GLN	DATE:	5/13/96

River alluvium in the vicinity of the quarry. These wells provide a reference for background values in the well field area and have been sampled by both the USGS (1992) and the DOE (1994). A summary of background values used at the quarry is provided in Table 8-11.

8.4.2 Monitoring Program

Groundwater monitoring is performed in both the alluvial and bedrock aquifers at the quarry (Figure 8-4). Three separate monitoring programs were employed for the quarry in 1995. The first program addressed sampling the Department of Energy wells and monitoring the quarry area to determine contaminant migration and the effects of quarry dewatering and bulk waste removal, which began in mid-1993 and were completed in late-1995. The frequency of sampling for each location was based on the distance of the well from the source or migration pathway. Monitoring wells on the quarry rim were sampled monthly for total uranium and nitroaromatic compounds, due to the changes in concentrations over time, to better establish the trend in concentrations at these locations, and to monitor the effects of quarry dewatering and bulk waste removal activities on the groundwater system. All locations were sampled at least annually for radiochemical parameters and were qualitatively analyzed for nitroaromatic degradation products.

The second program monitors the St. Charles County well field and the associated water treatment plant. Active production wells, the St. Charles County RMW-series monitoring wells, and untreated and treated water from the County's public drinking water treatment plant were sampled quarterly or semiannually for selected parameters. This portion of the monitoring program was developed by representatives of the Department of Energy, several State regulatory agencies, and St. Charles County.

The third program monitors the equalization basin and the two effluent ponds at the quarry water treatment plant (Figure 8-4). Monitoring wells MW-1035 through MW-1037, MW-1040, and MW-1041 were sampled quarterly and annually for selected parameters. The monitoring program was initially developed to meet the substantitive requirements of 40 CFR Part 264, Subpart F, and 10 CSR Part 25.7, which require the monitoring of contaminants of concern in the groundwater beneath storage facilities. The contaminants of concern were derived from the *Engineering Evaluation/ Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 40) and the

Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri (Ref. 41). This is discussed in Section 8.5.1.

The groundwater monitoring program at the quarry was dramatically impacted when the Missouri River flooded the St. Charles County well field from May until September 1995. Heavy spring rains also caused flooding of the Femme Osage Slough. This heavy precipitation resulted in the inundation of the well field. Nine monitoring well locations were not sampled during the second bimonthly period due to the flooding. These wells were fitted with compression fit caps prior to flooding to prevent floodwater inflow. One of the county's production wells (MW-PW03) was flooded and was not sampled during the second and third quarters. The remaining production wells were sampled during this period. The analysis indicated no detectable levels of total uranium.

8.4.3 Weldon Spring Quarry Monitoring Results

8.4.3.1 Quarry. Radiochemical Parameters. All groundwater monitoring wells at the quarry were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta. The uranium values continue to indicate that the highest levels occur in the bedrock downgradient from the quarry and in the alluvial material north of the Femme Osage Slough. The annual averages for the locations that exceed background are summarized in Table 8-12.

TABLE 8-12 Annual Averages for Total Uranium (pCi/l) Above Average Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1002	2.98	3.70	1.88
MW-1004	3246	4150	2520
MW-1005	1895	2190	1600
MW-1006	2563	3030	2010
MW-1007	39.33	64.0	21.8
MW-1008	1990	2580	1290

TABLE 8-12 Annual Averages for Total Uranium (pCi/l) Above Average Background at the Weldon Spring Quarry (Continued)

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1010	3.52	10.2	0.10
MW-1012	2.43	2.44	2.43
MW-1013	806.8	1030	687
MW-1014	1012	1120	903
MW-1015	295	333	243
MW-1016	185	205	164
MW-1019	2.92	5.09	0.75
MW-1020	3.06	4.47	1.64
MW-1027	352.7	430	275
MW-1030	48.76	77.2	18.6
MW-1031	75.1	110	54
MW-1032	731.67	993	555
MW-1033	2.97	4.30	1.48

Note 1: 1 pCi/l = 0.037 Bq/l.

The proposed U.S. Environmental Protection Agency total uranium drinking water standard of 20 μg/l (13.6 pCi/l) was exceeded at MW-1004, MW-1005, MW-1006, MW-1007, MW-1008, MW-1013, MW-1014, MW-1015, MW-1016, MW-1027, MW-1030, MW-1031, and MW-1032. All of these monitoring wells are located north of the Femme Osage Slough and have no direct impact on the drinking water sources in the Missouri River alluvium. The 4% of DCG for total uranium in discharge water, 24 pCi/l, was exceeded at MW-1004, MW-1005, MW-1006, MW-1007, MW-1008, MW-1013, MW-1014, MW-1015, MW-1016, MW-1027, MW-1030, MW-1031, and MW-1032; however, these wells are not located near any drinking water sources.

Gross alpha was also monitored at the quarry and well field. Eleven locations exceeded background for gross alpha and four of these exceeded the MCL of 15 pCi/l. No locations south

of the Femme Osage Slough exceeded the adjusted gross alpha MCL. The gross alpha data are summarized in Table 8-13.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed in 1995 at all groundwater monitoring locations at the quarry. Elevated isotopic levels were observed at locations MW-1004, MW-1027, and MW-1030. It is suspected that the elevated isotopic values in these wells resulted from bulk waste removal activities. Early 1994 operational data from the quarry pond had shown elevated levels of isotopes of radium and

TABLE 8-13 Annual Averages for Gross α (pCi/l) Above Average Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1004	3255	3270	3240
MW-1005	2770	2770	(a)
MW-1017	4.27	4.27	(a)
MW-1018	6.11	6.11	(a)
MW-1019	5.01	5.01	(a)
MW-1021	10.75	13.0	8.51
MW-1022	5.30	5.30	(a)
MW-1023	12.6	12.6	(a)
MW-1024	4.25	5.21	2.95
MW-1031	72	72	(a)

(a) Only one result reported for location.
Note 1: 1 pCi/l = 0.037 Bq/l.
MCL gross alpha = 15 pCi/l

thorium in the runoff from waste removal operations and groundwater collected in the pond, which likely was due to disturbance of bulk wastes in the quarry. These levels decreased late in 1995 when bulk waste activities were complete.

Monitoring well MW-1004 is located on the rim of the southeastern quarry wall. Monitoring wells MW-1027 and MW-1030 are located in the center of the quarry. Concentrations for 1995 which exceed background levels in these wells may be due to washdown of the quarry floor and walls or due to groundwater backflow to the quarry following quarry pond dewatering. The remainder of the wells with annual averages exceeding background values are located in the alluvium along the Femme Osage Slough. These locations are MW-1011, MW-1021, and MW-1024. The annual averages from above background locations are summarized in Table 8-14.

TABLE 8-14 Isotopic Radionuclide (pCi/l) Concentrations That Exceeded Two Standard Deviations (Upper 95% Confidence Interval) of Mean Background at the Weldon Spring Quarry

LOCATION	RA-226	RA-228	TH-228	TH-230
MW-1004	--	5.4	--	--
MW-1027	--	--	--	2.79
MW-1030	1.53	--	1.66	--

Note 1: Values reported in activity and radiological error.
Note 2: 1 pCi/l = 0.037 Bq/l.

Nitroaromatic Compounds. In 1995, samples from all quarry monitoring wells were analyzed for nitroaromatic compounds. Eleven locations yielded detectable concentrations of at least one of the six compounds analyzed during the 1995 sampling period. These monitoring wells are situated in the alluvial materials or bedrock downgradient of the quarry and north of the Femme Osage Slough. No detectable concentrations were observed south of the Femme Osage Slough. A summary of the annual averages for these locations is provided in Table 8-15.

TABLE 8-15 Annual Averages for Detectable Concentrations of Nitroaromatic Compounds (µg/l) at the Weldon Spring Quarry

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-1002	155	0.42	23.4	0.13	12.0	<0.04
MW-1004	0.93	0.33	12.1	0.46	0.85	<0.04
MW-1006	87.1	0.10	11.8	0.34	1.82	<0.04
MW-1007	<0.03	<0.09	<0.03	<0.03	0.01	<0.04
MW-1008	0.07	<0.09	0.28	<0.03	0.03	<0.04
MW-1013	<0.03	<0.09	<0.03	0.03	0.01	<0.04
MW-1015	6.50	0.12	3.50	0.20	0.20	<0.04
MW-1016	0.37	<0.09	0.43	<0.03	0.04	<0.04
MW-1027	0.04	<0.09	0.96	3.70	1.84	<0.04

TABLE 8-15 Annual Averages for Detectable Concentrations of Nitroaromatic Compounds (μg/l) at the Weldon Spring Quarry (Continued)

LOCATION	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	NB
MW-1030	<0.03	<0.09	<0.03	<0.03	0.01	<0.04
MW-1032	0.08	<0.09	0.51	0.18	0.05	<0.04

The Missouri drinking water quality standard for 2,4-DNT (0.11 μg/l) was exceeded at MW-1002, MW-1004, MW-1006, MW-1015, and MW-1032. These locations are north of the Femme Osage Slough. No MCLs have been established for the other nitroaromatic compounds in groundwater.

Sulfate. Groundwater analyses in 1995 indicated sulfate levels were elevated in the monitoring wells in the bedrock of the quarry rim and in the alluvial materials north of the Femme Osage Slough. Thirteen wells exceeded average background levels for sulfate. These wells are situated north of the slough with the exception of MW-1018 located south of the slough, downgradient of the area of greatest groundwater impact. Only two locations (MW-1005 and MW-1006) exceeded the secondary MCL of 250 mg/l. The annual averages for these wells are summarized in Table 8-16.

TABLE 8-16 Annual Averages for Sulfate (mg/l) Above Average Background at the Weldon Spring Quarry

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1004	162.1	220	90.4
MW-1005*	485	530	440
MW-1006*	353.8	360	340
MW-1008	228.7	230	226
MW-1009	204.5	220	190
MW-1013	86.33	97.0	73.0
MW-1014	94.0	110	83.1

TABLE 8-16 Annual Averages for Sulfate (mg/l) Above Average Background at the Weldon Spring Quarry (Continued)

LOCATION	ANNUAL AVERAGE	MAXIMUM	MINIMUM
MW-1015	126.3	140	109
MW-1016	147.7	153	140
MW-1018	95.3	110	76
MW-1030	87.3	103	76
MW-1032	195.3	250	136
MW-1042	93.8	93.8	--

* Exceeded secondary MCL of 250 mg/l.

8.4.3.2 St. Charles County Well Field.

Radiochemical Parameters: The St. Charles County production wells and the RMW-series monitoring wells were sampled semiannually for the radiochemical parameters Ra-226, Ra-228, and isotopic thorium. Gross alpha, gross beta, and total uranium were analyzed quarterly. A summary of the radiochemical annual averages is provided in Table 8-17. The second quarter samples could not be collected due to flooding in the well field and, therefore, could not be included in this summary. The annual averages for total uranium in the wells field remain at background. No production well exceeded the DCG of 24 pCi/l (4% of the DCG for discharge waters) for total uranium in drinking water systems, or the proposed groundwater standard of 20 μg/l (13.6 pCi/l).

The St. Charles County production wells, the RMW-series wells, and pretreated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant were sampled quarterly for gross alpha. The annual averages for these locations are within the statistical variation of background ranges for the Missouri River alluvium.

TABLE 8-17 Summary of Annual Averages of Radiochemical Parameters (pCi/l) for the St. Charles County Well Field

LOCATION	TOTAL URANIUM	GROSS ALPHA	RA-226	RA-228	TH-230	TH-232
MW-1024	0.40	4.25	1.36	2.27	0.78	0.15
MW-RMW1	0.83	8.32	0.93	1.87	0.26	0.16
MW-RMW2	5.03	5.28	0.30	1.87	0.16	0.19
MW-RMW3	0.68	3.20	0.78	2.50	0.19	0.18
MW-RMW4	1.32	1.92	0.30	1.36	0.16	0.22
MW-PW02	0.26	2.12	0.60	1.09	0.10	0.05
MW-PW03	1.78	2.48	0.75	0.89	0.15	0.14
MW-PW04	0.15	2.14	0.72	1.02	0.23	0.11
MW-PW05	0.19	2.84	0.86	0.83	0.30	0.09
MW-PW06	0.21	2.17	0.40	1.33	0.26	0.11
MW-PW07	0.21	2.80	0.17	1.64	0.06	<0.05
MW-PW08	0.53	2.57	0.52	0.89	0.14	0.14
MW-PW09	0.23	2.23	1.08	1.09	0.17	0.20
MW-RAWW	0.17	1.89	0.63	0.72	0.11	0.10
MW-FINW	0.18	0.94	0.25	0.45	0.08	0.10

Note 1: 1 pCi/l = 0.037 Bq/l.

The Missouri Drinking Water Standard of 0.555 Bq/l (15 pCi/l) for gross alpha was not exceeded at any of the production wells. The St. Charles County treatment plant finished waters were in compliance with the gross alpha level of 10 pCi/l as established in 40 CFR 141 and endorsed in Department of Energy Order 5400.5.

The Missouri Drinking Water Standard of 0.185 Bq/l (5 pCi/l) for combined Ra-226 and Ra-228 was not exceeded at any of the St. Charles County production well locations. No water quality standards have been established for isotopic thorium in drinking water.

Nitroaromatic Compounds. The St. Charles County production wells and the RMW-series monitoring wells were sampled quarterly for the six nitroaromatic compounds. No detectable concentrations were observed at any of these locations.

Sulfate. The St. Charles County production wells were sampled semiannually and the RMW-series monitoring wells were sampled quarterly for sulfate. The sulfate concentrations in the well field were slightly elevated for 1995 at MW-RMW3, MW-PW02, MW-PW03 MW-PW04, and MW-PW06. This is possibly due to Missouri River floodwater influences on the recharge of groundwater produced by these wells. The 1995 annual averages for the well field are summarized in Table 8-18. The secondary MCL for sulfate is 250 mg/l; this standard was not exceeded at any location in the well field.

Metals. Groundwater produced from each operating St. Charles County production well was analyzed semiannually and the RMW-series monitoring wells were sampled quarterly for arsenic and barium. The annual averages are summarized in Table 8-18. Except for MW-1024, MW-RMW1, MW-RMW-2, MW-RMW-3, and MW-RMW-4, which exceed background for arsenic, the concentrations for both of these metals in the well field area were within background ranges. The elevated arsenic values are likely the result of natural fluctuations of conditions in the alluvial system or use of insecticides when the well field was previously farmed. No indications of impact from quarry bulk wastes have been determined from historical data.

8.4.4 Trend Analysis

Statistical tests for time-dependent trends at the Weldon Spring Quarry were performed on historical and current data from select groundwater wells and parameters. Trending was performed on total uranium, nitroaromatic, and sulfate data.

Trend analyses were performed at monitoring locations based on historical data or knowledge of the quarry groundwater system. Total uranium trends were analyzed at locations downgradient of bulk waste sources and in areas of possible impact south of the slough. Nitroaromatic compounds were analyzed for at locations downgradient of bulk waste sources. Sulfate trend analysis was performed at locations downgradient of bulk waste sources and at all

TABLE 8-18 Annual Averages for Sulfate (mg/l), Arsenic (µg/l), and Barium (µg/l) in the St. Charles County Well Field

LOCATION	SULFATE	ARSENIC	BARIUM
MW-1024	10.2	10.9	290
MW-RMW1	33.8	9.57	556
MW-RMW2	22.0	49.03	320
MW-RMW3	83.0	34.0	376
MW-RMW4	22.7	31.3	236
MW-PW02	100	<3.0	355
MW-PW03	100	<3.0	335
MW-PW04	110	<2.0	320
MW-PW05	44.0	1.85	436
MW-PW06	83.0	1.90	392
MW-PW07	29.0	7.40	547
MW-PW08	39.0	4.60	447
MW-PW09	31.5	2.45	498
MW-RAWW	65.2	1.13	368
MW-FINW	66.6	1.17	91.0

locations adjacent to the south side of the slough, due to recent changes in levels in sulfate in this area.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test, which is described in Section 8.3.4 of this document.

The trend analysis indicates the presence of a trend and its direction upward or downward, and the slope is estimated in concentration units per year. A 95% confidence interval was calculated to indicate the variability in the values about this trend line. These

values are to be interpreted as indicators and are not for the prediction of future concentrations, but to indicate areas that should be more closely monitored in the future.

Nitroaromatic Compound Trend Analysis

Trend analysis has been performed since 1992 for the nitroaromatic data at the quarry. Twelve of the 36 DOE monitoring locations were selected for trend analysis based on the previously outlined criteria. The summary of the nitroaromatic trend analysis is presented in Table 8-19. Nitrobenzene was not included in the statistical analysis because levels are consistently below detection limits during sampling at the quarry. Based on the results of the trending analysis, upward trends are present in the bedrock of the quarry rim at two locations (MW-1004 and MW-1027). Nitroaromatic trend directions were downward in most wells that have exhibited upward trends from 1991 to 1994. These decreases may potentially be the result of bulk waste removal at the quarry.

Total Uranium Trend Analysis

Total uranium trends for 1994-1995 data were stable or downward at all locations except north of the Femme Osage Slough where two locations (MW-1014 and MW-1031) showed upward trends. Quarry rim wells trends were downward or stationary, and as in nitroaromatic compound trends, may be due to quarry bulk waste removal. The uranium trend analyses are summarized in Table 8-20.

Sulfate Trend Analysis

Sulfate trends at the quarry were stationary for 1994-1995 with the exception of two locations north of the Femme Osage Slough (MW-1016 and MW-1031) and one location hydraulically upgradient of the quarry (MW-1035). It is possible that these increases are due to flooding during the last three years. Two locations at the quarry rim (MW-1002 and MW-1007) that previously showed upward trends have stabilized during the 1994-1995 trend timeframe. This may be due to hydraulic gradient reversal at the quarry due to quarry pond dewatering during remedial activities. The sulfate trend analysis is summarized in Table 8-21.

TABLE 8-19 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary

WELL ID	LOCATION	COMPOUND	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
			1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93	1994-1995
MW1002	Bedrock-East rim	2,4-DNT	35	19	23	6	5	1	S	U	D	0.04	0.12	-0.04	0.00, 0.07	0.10, 0.17	-0.07, -0.01
		2,6-DNT	34	19	22	0	0	0	S	U	D	0.42	15.10	-6.00	-3.00, 3.67	6.03, 22.48	-8.00, -1.00
		1,3-DNB	34	19	22	1	1	1	U	U	D	0.16	0.24	-0.20	0.10, 0.19	0.17, 0.35	-0.30, -0.08
		2,4,6-TNT	34	19	22	0	0	0	S	U	D	18.83	88.00	-47.00	1.63, 45.00	66.50, 139.70	-68.78, -28.93
		1,3,5-TNB	34	19	22	0	0	0	S	U	D	89.08	608.75	-272.50	5.05, 269.72	430.24, 800.00	-370.00, -200.66
MW1004	Bedrock-rim	2,4-DNT	36	19	24	0	0	0	D	S	S	-1.03	0.30	0.02	-1.48, -0.78	-0.19, 0.90	0.00, 0.05
		2,6-DNT	36	19	24	1	0	1	D	S	S	-1.82,	-0.35	0.14	-2.40, -1.37	-1.20, 0.20	-0.03, 0.47
		1,3-DNB	35	19	23	34	19	22	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
		2,4,6-TNT	35	19	23	0	0	0	D	S	S	-3.64	1.00	1.83	-5.64, -1.99	-2.56, 4.50	-0.20, 4.89
		1,3,5-TNB	35	19	23	0	0	0	D	S	S	-1.94	0.56	-0.04	-2.67, -0.89	-0.50, 1.85	-0.42, 0.36
MW1005	Bedrock-rim	2,4-DNT	32	17	16	4	1	8	D	D	D	-0.03	-0.03	-0.003	-0.04, -0.02	-0.04, -0.02	-0.12, 0.00

TABLE 8-19 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary (Continued)

WELL ID	LOCATION	COMPOUND	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
			1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93	1994-1995
		2,6-DNT	32	17	16	4	0	9	D	D	D	-0.01	-0.01	-0.01	-0.02, -0.01	0.02, -0.01	-0.03, 0.00
MW1006	Alluvium-North of Slough	2,4-DNT	21	--	9	1	--	0	S	-	S	0.03	--	0.01	-0.01, 0.05	--	-0.25, 0.27
		2,6-DNT	21	--	9	0	--	0	D	--	S	-0.80	--	-0.45	-1.40, -0.37	--	-1.77, 1.18
		1,3-DNB	21	--	9	20	--	6	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		2,4,6-TNT	21	--	9	0	--	0	S	--	S	-3.05	--	-2.12	-6.98, 0.00	--	-16.30, 5.42
		1,3,5-TNB	21	--	9	0	--	0	S	--	S	-10.38	--	-23.18	-32.45, 10.90	--	-196.60, 99.51

TABLE 8-19 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary (Continued)

WELL ID	LOCATION	COMPOUND	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
			1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93	1994-1995
MW1015	Bedrock-North of Slough	2,4-DNT	23	18	9	4	3	1	S	U	D	[b]	0.01	-0.01	-0.01, 0.01	0.00, 0.02	-0.02, -0.01
		2,6-DNT	23	18	9	1	0	1	D	S	S	-0.21	-0.20	-0.03	-0.27, -0.13	-0.30, -0.04	-0.07, 0.13
		1,3-DNB	23	18	9	7	6	2	S	S	S	0.04	0.05	-0.06	0.00, 0.06	0.00, 0.11	-0.16, 0.06
		2,4,6-TNT	23	18	9	0	0	0	D	S	S	-5.60	-4.00	-0.65	-9.50, -3.96	-10.16, 1.77	-1.98, 0.39
		1,3,5-TNB	23	18	9	0	0	0	D	S	S	-47.25	-45.50	-1.49	-71.00, -20.02	-106.62, 0.00	-5.75, 1.88
		NB	1	1	0	1	1	0	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
MW1016	Alluvium-North of Slough	2,4-DNT	22	--	9	22	--	9	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		2,6-DNT	22	--	9	1	--	1	D	--	S	-0.06	--	[b]	-0.09, -0.03	--	-0.03, 0.03
		2,4,6-TNT	22	--	9	0	--	1	D	--	S	-1.06	--	0.05	-2.53, -0.69	--	-0.16, 0.37
		1,3,5-TNB	22	--	9	0	--	1	D	--	S	-5.66	--	0.01	-13.61, -4.30	--	-3.94, 0.61

TABLE 8-19 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary (Continued)

WELL ID	LOCATION	COMPOUND	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
			1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93	1994-1995
MW1027	Bedrock-Rim	2,4-DNT	25	16	10	0	0	0	S	S	U	-1.38	0.80	3.65	-3.50, -0.32	-2.70, 5.99	0.31, 4.15
		2,6-DNT	25	16	10	0	0	0	D	S	S	-0.91	-0.20	(b)	-1.50, -0.36	-1.30, 0.90	-1.12, 1.46
		2,4,6-TNT	25	16	10	0	0	0	D	S	D	-3.38	2.63	-3.08	-9.06, -1.16	-8.00, 12.25	-6.91, -0.39
MW1030	Bedrock-Rim	2,4-DNT	28	11	12	1	1	3	S	S	D	(b)	0.02	-0.03	-0.01, 0.02	0.00, 0.06	-0.08, -0.01
		2,6-DNT	28	11	12	6	6	2	U	U	S	0.01	0.05	-0.02	-0.00, 0.06	0.00, 0.09	-0.17, 0.00
		2,4,6-TNT	28	11	12	11	8	7	S	(c)	S	0.01	(c)	-0.02	0.00, 0.11	(c)	-0.10, 0.00
MW1032	Bedrock-North of Slough	2,4-DNT	20	16	9	1	0	3	S	S	S	-0.01	0.08	-0.01	-0.04, 0.03	-0.02, 0.18	-0.11, 0.51
		2,6-DNT	20	16	9	1	0	3	D	S	S	-0.11	-0.04	(b)	-0.20, -0.04	-0.27, 0.16	-0.03, 0.12
		2,4,6-TNT	20	16	9	7	3	7	S	S	S	-0.04	0.26	(b)	-0.18, 0.00	-0.12, 0.91	0.00, 0.86

TABLE 8-19 Quarry Groundwater Wells Nitroaromatic Trend Analysis Summary (Continued)

WELL ID	LOCATION	COMPOUND	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
			1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93	1994-1995
MW1034	Bedrock-background	2,4-DNT	18	--	7	18	--	7	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		2,6-DNT	18	--	7	18	--	7	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		1,3-DNB	18	--	7	18	--	7	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		2,4,6-TNT	18	--	7	18	--	7	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		1,3,5-TNB	18	--	7	18	--	7	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
MW1035	Alluvium-background	2,4-DNT	18	--	8	18	--	8	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		2,6-DNT	18	--	8	18	--	8	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		1,3-DNB	18	--	8	18	--	8	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		2,4,6-TNT	18	--	7	18	--	7	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)
		1,3,5-TNB	18	--	8	18	--	8	(c)	--	(c)	(c)	--	(c)	(c)	--	(c)

D Downward
S Stationary
U Upward
(a) Location not selected for trending
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* Inclusive

TABLE 8-20 Quarry Groundwater Wells-Total Uranium Trend Analysis Summary-(ALPHA-0.05)

WELL ID	LOCATION	NO OF OBSERVATIONS			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (pCi/l/yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)		
		1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91 to 7/93 INCLUSIVE	1994-1995
MW1004	Bedrock-rim	35	19	16	0	0	0	D	S	S	-810.00	-300.00	250.00	-1120.00, -437.92	-909.88, 149.95	-251.64, 980.21
MW1005	Bedrock-rim	33	18	12	0	0	0	S	D	S	-60.00	-360.00	-15.00	-204.17, 90.00	-476.00, -200.00	-805.71, 769.14
MW1006	Alluvium-North of Slough	21	--	8	0	--	0	S	--	S	-198.33	--	-420.00	-501.61, 83.23	--	-850.18, 1303.33
MW1007	Alluvium-North of Slough	22	18	9	0	0	0	S	S	S	40.90	90.25	-166.10	-15.15, 183.62	-9.06, 256.50	-830.80, 22.24
MW1008	Alluvium-North of Slough	20	--	9	0	--	0	D	--	S	-756.00	--	-410.00	-1050.00, -470.00	--	-1161.86, 397.16
MW1009	Alluvium-North of Slough	20	--	8	4	--	2	S	--	S	0.52	--	-0.70	-1.28, 2.44	--	-9.23, 8.39
MW1013	Bedrock-North of Slough	21	--	9	0	--	0	D	--	S	-53.17	--	(b)	-84.38, -21.09	--	-76.61, 165.02
MW1014	Alluvium-North of Slough	21	--	9	0	--	0	S	--	S	-86.25	--	93.00	-120.00, 8.56	--	1.36, 224.30
MW1015	Bedrock-North of Slough	23	18	8	0	0	0	D	S	S	-338.17	-310.00	-45.00	-480.00, -227.99	-559.86, -49.47	-135.14, 27.37
MW1016	Alluvium-North of Slough	23	--	8	0	--	0	D	--	S	-165.75	--	15.00	-240.01, -129.00	--	-21.23, 46.21
MW1023	Alluvium-South of Slough	16	--	9	8	--	1	S	--	S	(b)	--	0.34	-0.08, 0.14	--	-1.05, 1.49

TABLE 8-20 Quarry Groundwater Wells-Total Uranium Trend Analysis Summary-(ALPHA-0.05) (Continued)

WELL ID	LOCATION	NO OF OBSERVATIONS			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (pCi/l/yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (pCi/l/yr)		
		1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91 to 7/93 INCLUSIVE	1994-1995
MW1027	Bedrock-rim	30	19	10	0	0	0	D	S	S	-112.00	-68.75	4.00	-203.62, -38.72	-245.49, 47.00	-76.60, 119.48
MW1030	Bedrock-rim	27	14	13	2	2	0	U	S	D	32.46	0.37	-55.45	5.62, 67.34	-1.91, 4.70	-151.74, -12.25
MW1031	Bedrock-North of Slough	20	--	8	0	--	0	S	--	U	-3.00	--	54.80	-6.56, 0.40	--	33.20, 89.68
MW1032	Bedrock-North of Slough	21	16	8	0	0	0	S	U	S	-11.00	348.00	-71.00	-200.00, 159.64	74.00, 648.00	-305.25, 651.37
MW1034	Bedrock-Background	20	--	7	3	--	0	S	--	S	0.38	--	-2.11	-0.11, 0.90	--	N too small, -0.20
MW1035	Alluvium-Background	18	--	8	7	--	1	S	--	S	0.02	--	0.06	-0.09, 0.45	--	-26.42, 0.30

D Downward
S Stationary
U Upward
(a) Location
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* Inclusive

TABLE 8-21 Quarry Groundwater Wells Sulfate Trend Analysis Summary

WELL ID	LOCATION	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
		1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995
MW1002	Bedrock - East rim	28	17	11	0	0	0	S	U	S	2.20	11.48	5.85	-3.26, 6.65	4.73, 16.10	-1.71, 12.64
MW1004	Bedrock - rim	28	--	8	0	--	0	D	--	S	-43.67	--	31.00	-70.85, -16.40	--	-35.36, 116.48
MW1005	Bedrock - rim	25	17	6	0	0	0	S	D	S	2.00	-32.25	227.50	-14.44, 20.32	-42.84, -16.33	N too small, 161.70
MW1006	Alluvium - North of Slough	18	--	6	0	--	0	S	--	S	-17.58	--	-11.00	-34.31, 4.66	--	N too small, 6.97
MW1007	Alluvium - North of Slough	19	14	7	1	1	0	S	U	S	8.85	54.95	-18.90	-17.76, 35.19	11.74, 98.93	N too small, 12.00
MW1008	Alluvium - North of Slough	19	--	6	0	--	0	S	--	S	-6.33	--	-7.50	-15.00, 4.08	--	N too small, -1.00
MW1009	Alluvium - North of Slough	19	--	6	0	--	0	D	--	S	-40.00	--	13.50	-48.66, -25.00	--	N too small, 15.18
MW1013	Bedrock - North of Slough	20	--	8	0	--	0	D	--	S	-9.15	--	4.25	-11.43, -5.67	--	-9.35, 14.43
MW1014	Alluvium - North of Slough	18	--	5	0	--	0	D	--	S	-9.55	--	5.35	-14.16, -4.00	--	N too small, 4.30

TABLE 8-21 Quarry Groundwater Wells Sulfate Trend Analysis Summary (Continued)

WELL ID	LOCATION	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
		1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/81-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995
MW1015	Bedrock - North of Slough	22	18	7	0	0	0	D	D	S	-72.26	-70.00	9.00	-91.00, -55.47	-99.72, -34.65	-15.31, 22.31
MW1016	Alluvium - North of Slough	22	--	7	0	--	0	D	--	S	-59.50	--	23.50	-73.00, -36.95	--	8.08, 36.96
MW1018	Alluvium - South of Slough	17	--	10	1	--	0	S	--	S	13.10	--	14.65	-7.24, 25.08	--	-14.18, 63.72
MW1020	Alluvium - South of Slough	17	--	9	3	--	1	S	--	S	4.75	--	-1.90	-5.75, 10.02	--	-31.24, 59.32
MW1021	Alluvium - South of Slough	16	--	9	7	--	6	S	--	S	(b)	--	-0.37	-0.93, 0.26	--	-4.74, 4.50
MW1023	Alluvium - South of Slough	16	--	10	2	--	0	S	--	S	-0.12	--	0.82	-1.42, 0.99	--	-0.99, 1.36
MW1027	Bedrock - rim	20	16	5	0	0	0	S	S	S	-9.00	0.25	0.40	-15.72, 0.22	-9.99, 8.70	N too small
MW1029	Bedrock - East rim	19	--	5	0	--	0	D	--	S	-7.95	--	8.50	-14.28, -4.17	--	N too small

TABLE 8-21 Quarry Groundwater Wells Sulfate Trend Analysis Summary (Continued)

WELL ID	LOCATION	NO OF OBSERVATIONS (N)			NO. OF NON-DETECT DATA			TREND DIRECTION			SLOPE (mg/l yr)			95% UPPER AND LOWER CONFIDENCE INTERVAL ON SLOPE (mg/l/yr)		
		1991-1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991 1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995	1991-1994	1/91-7/93*	1994-1995
MW1030	Bedrock - rim	22	15	6	1	1	0	S	S	S	9.00	-0.05	-4.90	-6.30, 22.91	-19.11, 25.68	N too small, 8.76
MW1031	Bedrock - North of Slough	20	--	8	0	--	0	S	--	U	-1.90	--	40.70	-4.42, 0.24	--	31.03, 67.74
MW1032	Bedrock - North of Slough	19	15	7	0	0	0	S	S	S	-7.25	-3.00	-3.50	-19.46, 0.50	-18.30, 13.60	-114.10, 122.64
MW1033	Bedrock - South of Slough	15	--	9	1	--	3	S	--	S	-2.25	--	-4.33	-4.78, 0.10	--	-8.45, 2.33
MW1034	Bedrock - Background	19	--	8	0	--	0	S	--	S	-3.18	--	-12.50	-10.78, 2.39	--	-23.78, 12.96
MW1035	Alluvium - Background	18	--	8	0	--	0	S	--	U	-1.05	--	6.50	-2.23, 0.79	--	4.71, 16.29

D Downward
S Stationary
U Upward
(a) Location not selected for trending
(b) Trend direction stationary; therefore, no slope to data
(c) No detectable concentrations reported for time period; therefore, no trending performed
* Inclusive

8.4.5 Geochemical Characterization

A select group of groundwater monitoring wells was chosen for geochemical characterization. These analyses were performed as part of a 2-year program to evaluate groundwater quality, contaminant migration, and remediation alternatives. Wells were selected to provide a broad representation of the different geologic media present at the quarry, which include bedrock (MW-1002, MW-1005, MW-1013, MW-1028, MW-1031, MW-1032, MW-1033, and MW-1034), alluvium (MW-1014, MW-1018, MW-1019, MW-1021, MW-1022, MW-1038, and MW-1039), and Missouri River alluvium (MW-RMW1, MW-RMW2, MW-PW02, and MW-PW09). The geochemical characterization includes an extensive list of anions, cations, and metals that are not routinely monitored by the WSSRAP. A summary of the analyses of the data and conclusions drawn from this multi-year investigation will be provided in the *Remedial Investigation Report for the Quarry Residuals Operable Unit*.

8.5 Waste Treatment Facilities

8.5.1 Monitoring Program

Groundwater monitoring wells have been placed around three waste management units: the quarry and site water treatment plant equalization basins, and the temporary storage area (see Figures 8-2 and 8-4). These wells were installed to detect contaminants in the uppermost water units beneath these storage facilities in order to comply with the requirements of 40 CFR 264, Subpart F, and 10 CSR 264, Subpart F. The monitoring parameters were derived from previous evaluations performed and documented in the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 40) and the *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 41).

The detection monitoring program consists of quarterly sampling for the following parameters:

- Total uranium.
- Anions (nitrate, sulfate, chloride, and fluoride).
- Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver).

- Nitroaromatic compounds.

Annual sampling is performed for the following parameters:

- Radiochemical parameters (Ra-226, Ra-228, Th-230, Th-232, U-234, and U-238).
- Polychlorinated biphynels (PCBs).
- Polynuclear aromatic hydrocarbons (PAH).
- Pesticides (endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP Silvex).

Constituent concentrations at the monitoring wells were compared with previously determined baseline concentrations for each well. If there was statistically significant evidence of contamination (concentration exceeds baseline by three standard deviations), a program of increased monitoring and/or an evaluation of the leachate collected within the liners of the basins or storage area was initiated.

8.5.2 Site Water Treatment Plant and Temporary Storage Area Monitoring Results

Collection of baseline data for the wells surrounding the equalization basin for the site water treatment plant and the temporary storage area was completed in December of 1994. The baseline dataset for each monitoring well was established with a minimum of eight samples collected on a quarterly basis. A statistical summary of these baseline data for wells MW-2035 through MW-2043 can be found in Table 8-22. Monitoring data collected during 1995 were compared with the baseline data to identify significant changes in groundwater quality potentially attributable to operation of these facilities.

Primary and secondary drinking water standards were not exceeded, except for nitrate at well locations MW-2037 through MW-2041, mercury at locations MW-2036 and MW-2038, selenium at the MW-2038 location, and 2,4-DNT at locations MW-2037 and MW-2038. Elevated selenium and nitrate levels are potentially due to the facility's close proximity to the raffinate pits.

TABLE 8-22 Baseline for the Detection Monitoring System at the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic (µg/l)	2.25	2.09	1.82	5.77	2.43	4.12	4.35	3.41	2.10
Barium (µg/l)	107	333	250	563	240	962	347	590	344
Cadmium (µg/l)	3.91	3.89	3.67	3.67	6.98	4.04	4.20	3.80	3.79
Chromium (µg/l)	4.21	4.33	3.83	3.83	14.1	14.1	18.4	6.62	4.52
Lead (µg/l)	4.08	2.17	1.65	1.65	1.50	3.30	8.53	2.40	2.81
Mercury (µg/l)	0.14	0.14	3.40	4.37	0.15	0.12	0.59	0.13	0.15
Selenium (µg/l)	4.71	1.86	20.0	24.9	24.5	9.42	96.6	4.11	7.11
Silver (µg/l)	5.78	6.07	6.08	6.08	13.8	5.40	10.3	6.18	4.96
Uranium (pCi/l)	1.93	1.64	2.17	2.32	4.12	4.64	8.35	3.33	2.34
Nitrate (mg/l)	2.05	5.03	668	2271	117	455	2256	13.8	8.03
Sulfate (mg/l)	6.89	5.64	177	132	54.6	27.9	196	39.5	20.8
1,3,5-TNB (µg/l)	0.02	0.02	0.29	0.37	0.02	0.02	0.02	0.02	0.02

TABLE 8-22 Baseline for the Detection Monitoring System at the Weldon Spring Site Water Treatment Plant and Temporary Storage Area (Continued)

PARAMETER	MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
TNT (µg/l)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2,4-DNT (µg/l)	0.02	0.02	0.79	2.14	0.02	0.02	0.02	0.02	0.09
2,6-DNT (µg/l)	0.01	0.01	0.19	0.41	0.01	0.01	0.01	0.01	0.01

Note: 1 pCi/l = 0.037 Bq/l.

Baseline concentrations for metals, with the exceptions of cadmium, selenium, and silver, were slightly exceeded at MW-2035, MW-2037 through MW-2041, and MW-2043. These apparent concentration elevations are most likely attributable to changes in sample collection and preparation methodologies rather than actual groundwater conditions. Baseline values were established from analytical results of filtered samples collected during 1993 and 1994. Beginning in 1995, groundwater samples were not filtered due to a change in project sampling procedures pursuant to EPA sampling guidelines. Metals potentially adhering to suspended solids or precipitates, which had been filtered out prior to 1995, were not filtered from the 1995 samples. There is no evidence that the integrity of the water treatment facilities or temporary storage area (TSA) basins has been breached. This negative evidence includes no elevated metals detected in collected leachate and no increased volume of leachate at these facilities.

Nitrate baseline was exceeded at location MW-2043 at the site water treatment facility equalization basin. All other locations at the water treatment plant and TSA are decreasing in nitrate concentrations. Sulfate baselines are exceeded in three locations. One above-baseline location, MW-2038, in which sulfate concentrations had been steadily rising in 1993 to 1994, has apparently stabilized during 1995. None of the locations exceeded the drinking water standard of 250 mg/l.

Nitroaromatic compounds were detected at locations MW-2037 through MW-2039. There were no pre-1995 detections at the MW-2039 location; therefore, the baseline was exceeded. The two other locations with detectable nitroaromatics were below baseline concentrations.

No concentrations of total uranium, pesticides, or PCBs were above their respective baselines at any of the detection locations for the water treatment facility and TSA. The 1995 detection monitoring data for the site water treatment plant and the TSA are summarized in Table 8-23.

8.5.3 Quarry Water Treatment Plant Monitoring Results

Monitoring wells MW-1035 through MW-1039 were installed in 1991 to monitor the shallow groundwater in the vicinity of the quarry water treatment plant. In 1993, two additional monitoring wells, MW-1040 and MW-1041, were installed closer to the equalization basin to

TABLE 8-23 Summary of the 1995 Detection Monitoring Data for the Weldon Spring Site Water Treatment Plant and Temporary Storage Area

PARAMETERS		MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
Arsenic µg/l	Average max/min	<DL <2.0	<DL <2.0	2.44 6.80/<2.0	1.24 2.4/<2.0	1.79 6.2/<2.0	1.42 2.90/<2.0	<DL <2.0	1.16 2.10/<2.0	<DL <2.0
Barium µg/l	Average max/min	89.9 99.9/86.5	277 295/264	76.9 83.7/61.7	172 200/121	243 434/185	721 881/562	213 228/200	490 532/446	278 301/253
Cadmium µg/l	Average max/min	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	<DL <3.0	1.03 3.5/<3.0	<DL <3.0	<DL <3.0	<DL <3.0
Chromium µg/l	Average max/min	3.02 5.2/<1.0	2.17 4.9/<1.0	4.58 11.4/<1.0	6.03 14.0/<1.0	8.19 10.9/5.9	16.7 24.7/5.3	4.51 11.0/1.0	4.16 8.90/1.20	5.82 15.9/2.30
Lead µg/l	Average max/min	1.24 2.6/<1.0	<DL <2.0	0.80 1.5/<1.0	0.84 2.30/<1.0	1.46 3.0/<1.0	3.70 12.0/<1.0	1.71 7.80/<1.0	<DL <1.0	<DL <1.0
Mercury µg/l	Average max/min	<DL <2.0	0.39 2.60/<0.1	2.31 3.6/0.86	3.41 4.5/2.1	<DL <0.2	<DL <0.2	<DL <0.2	0.12 0.22/<0.2	<DL <0.2
Selenium µg/l	Average max/min	1.43 2.1/<2.0	<DL <3.0	5.55 8.1/<3.0	13.4 20.0/9.3	7.89 10.8/5.70	4.62 6.1/<3.0	14.2 21.7/11.3	2.29 3.40/<3.0	3.87 5.8/<3.0
Silver µg/l	Average max/min	<DL <2.0	<DL <2.0	<DL <2.0	1.49 6.9/<2.0	<DL <2.0	1.78 7.1/<2.0	<DL <2.0	<DL <2.0	<DL <2.0
Total Uranium pCi/l	Average max/min	0.37 1.40/0.32	0.76 1.20/0.57	1.14 1.83/0.85	1.26 1.75/0.88	3.51 6.00/2.16	2.45 3.33/1.73	3.35 4.45/2.26	2.68 3.10/1.98	1.72 1.96/1.46
Nitrate mg/l	Average max/min	0.46 0.63/0.39	3.23 4.02/2.90	239 296/34	807 900/757	41.6 52/32	187 230/142	280 319/240	5.45 6.07/4.84	5.90 6.55/5.17
Sulfate mg/l	Average max/min	2.53 5.00/1.85	4.33 5.00/3.82	130 136/120	106 100/110	39.6 61.0/32.0	9.79 14.0/2.70	46.3 76.0/35.0	30.9 55.0/21.8	14.7 15.1/13.7

TABLE 8-23 Summary of the 1995 Detection Monitoring Data for the Weldon Spring Site Water Treatment Plant and Temporary Storage Area (Continued)

PARAMETERS		MW-2035	MW-2036	MW-2037	MW-2038	MW-2039	MW-2040	MW-2041	MW-2042	MW-2043
TNT µg/l	Average max/min	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03	<DL <0.03
2,4-DNT µg/l	Average max/min	<DL <0.03	<DL <0.03	0.52 0.56/0.42	1.66 1.8/1.6	0.04 0.12/<0.03	<DL <0.03	<DL <0.03	<DL <0.03	0.07 0.09/0.05
2,6-DNT µg/l	Average max/min	<DL <0.01	<DL <0.01	0.12 0.13/0.10	0.31 0.33/0.29	0.43 1.7/<0.01	<DL <0.01	<DL <0.01	<DL <0.01	<DL <0.01

better monitor the waste storage unit. Baseline has been established for these newer wells utilizing 1994 and 1995 quarterly data. Monitoring wells MW-1038 and MW-1039 were deleted from this monitoring program because they were located cross gradient from the equalization basin at a distance too far to adequately monitor the basin and are possibly downgradient of contaminant sources in the quarry.

The concentrations at the wells were compared to baseline for the parameters. The baseline parameters for each well are presented in Table 8-24 and the summary of detection monitoring results is given in Table 8-25. Samples were analyzed for nitroaromatic compounds, pesticides, and PCBs. The baselines and analytical results are not shown in either table because these compounds do not naturally occur and have not been detected in the monitoring system.

The results of the comparison of the monitoring data to baseline indicated that no wells exceeded background for Ra-226, Ra-228, isotopic thorium, or isotopic uranium during 1995. Total uranium levels remain within baseline for all wells at the water treatment facility detection monitoring network.

Monitoring wells MW-1036 and MW-1037 had levels which exceeded baseline for sulfate during 1995. Monitoring well MW-1036 had concentrations exceeding baseline for sulfate in the second and third quarters, and MW-1037 had exceeded baseline for the second, third, and fourth quarters. These levels are possibly due to the flooding of the lowlands surrounding the water treatment basins during the spring and summer of 1995. Similar levels were observed in these wells during the floods that occurred in 1993 and 1994. Subsequent sulfate values have returned to within baseline for both wells.

Chloride baseline concentrations were exceeded in all samples collected from monitoring wells MW-1035 and MW-1036. The sources of these excursions is unknown, but it is unlikely that the water treatment facility is contributing to the chloride concentrations because one of the wells, MW-1035 is hydraulically upgradient from the facility. The remaining monitoring wells, with the exception of MW-1036, do not exceed baseline and are located closer to the treatment facility than MW-1035. A potential source of the chloride is deicing agent applied to Missouri

TABLE 8-24 Baseline for the Detection Monitoring System at the Weldon Spring Quarry Water Treatment Plant

PARAMETER	MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	2.66	9.70	3.08	12.0	7.56
U-234 (pCi/l)	12.1	(a)	4.95	10.8	5.79
U-238 (pCi/l)	13.2	(a)	3.25	6.72	3.45
Ra-226 (pCi/l)	1.32	0.25	0.72	2.17	1.47
Ra-228 (pCi/l)	0.81	1.00	1.58	1.79	1.25
Th-230 (pCi/l)	1.23	2.94	0.48	0.88	1.41
Th-232 (pCi/l)	0.35	0.34	0.40	0.39	0.35
Chloride (mg/l)	6.82	102	11.8	16.0	8.34
Fluoride (mg/l)	0.28	0.18	0.71	0.12	0.26
Nitrate (mg/l)	0.37	0.32	0.82	0.28	0.32
Sulfate (mg/l)	70.0	82.0	55.5	186	52.8
Arsenic (µg/l)	6.09	4.71	5.50	9.83	8.64
Barium (µg/l)	315	351	752	330	553
Cadmium (µg/l)	3.18	3.61	3.44	3.96	3.67
Chromium (µg/l)	4.81	7.57	7.57	19.6	15.5
Lead (µg/l)	1.59	2.06	2.06	2.72	5.84
Mercury (µg/l)	0.18	0.20	0.17	0.42	0.58
Selenium (µg/l)	7.81	3.63	5.09	5.63	5.28
Silver (µg/l)	4.99	4.78	4.78	5.69	8.45

(a) No data available for determination of baseline.
Note: 1 pCi/l = 0.037 Bq/l.

TABLE 8-25 Summary of the 1995 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant

PARAMETER		MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Uranium, total (pCi/l)	average	0.44	6.29	1.37	4.23	3.43
	max/min	0.61/0.35	8.54/4.54	2.26/0.35	7.21/2.27	5.6/3.3
U-234 (pCi/l)	average	0.39	2.42	2.80	5.06	3.47
	max/min	(a)	(a)	(a)	(a)	(a)
U-238 (pCi/l)	average	0.51	1.59	1.68	4.16	3.02
	max/min	(a)	(a)	(a)	(a)	(a)
Ra-226 (pCi/l)	average	0.61	<0.33	0.53	1.34	0.45
	max/min	(a)	(a)	(a)	(a)	(a)
Ra-228 (pCi/l)	average	0.22	<0.50		0.84	<0.10
	max/min	(a)	(a)	(a)	(a)	(a)
Th-230 (pCi/l)	average	0.67	0.20	0.71	0.60	0.47
	max/min	(a)	(a)	(a)	(a)	(a)
Th-232 (pCi/l)	average	<0.10	<0.06	<0.01	0.16	<0.21
	max/min	(a)	(a)	(a)	(a)	(a)
Chloride (mg/l)	average	18.9	129	3.46	9.83	4.80
	max/min	25.2/14.9	196/91.1	4.69/1.20	13.1/7.45	5.79/3.68
Fluoride (mg/l)	average	0.14	0.12	0.36	0.12	0.12
	max/min	0.20/<DL	0.13/<DL	0.50/0.24	0.13/0.10	<DL
Nitrate (mg/l)	average	<0.25	0.35	0.20	<0.10	0.08
	max/min	<DL	0.74/0.14	0.49/<DL	0.17/0.04	0.13/<DL
Sulfate (mg/l)	average	46.2	111.3	252	114.2	43.5
	max/min	53.8/42.5	207/30.1	428/28.0	141/58.0	50.6/26.9
Arsenic (µg/l)	average	2.00	5.48	5.10	3.78	2.12
	max/min	3.20/<DL	8.5/2.9	6.0/3.2	8.00/2.00	4.00/1.60
Barium (µg/l)	average	280	178	359	297	387
	max/min	324/223	246/103	478/305	524/189	524/240

TABLE 8-25 Summary of the 1995 Detection Monitoring Data for the Weldon Spring Quarry Water Treatment Plant (Continued)

PARAMETER		MW-1035	MW-1036	MW-1037	MW-1040	MW-1041
Cadmium (µg/l)	average	<3.0	<3.0	<3.0	1.19	1.57
	max/min	<DL	<DL	0.34/<DL	1.5/<0.5	3.10/<DL
Chromium (µg/l)	average	9.28	7.24	15.6	12.6	8.02
	max/min	21.9/5.60	11.7/<DL	27.3/3.3	30.0/3.10	15.7/1.70
Lead (µg/l)	average	1.77	1.38	3.65	2.33	2.00
	max/min	3.20/<DL	3.0/<DL	8.90/<DL	5.0/1.1	4.80/<DL
Mercury (µg/l)	average	<0.20	<0.80	<0.20	<0.20	<0.08
	max/min	<DL	<DL	<DL	<DL	<DL
Selenium (µg/l)	average	<4.0	1.58	1.68	<2.5	<2.00
	max/min	<DL	2.50/<DL	2.40/<DL	<DL	<DL
Silver (µg/l)	average	2.93	1.58	3.48	<2.0	3.77
	max/min	9.30/<DL	4.50/<DL	7.60/<DL	<DL	8.90/<DL

(a) Location sampled once during 1995; therefore no maximum or minimum reported.
Note: 1 pCi/l = 0.037 Bq/l.

State Route 94, which is routed along the northern perimeter upgradient of the quarry water treatment facility. The highest concentrations were detected during second quarter 1995 monitoring.

Metals concentrations exceeded baselines in each of the detection monitoring wells. The highest concentrations were detected in the wells from April to July 1995. Chromium levels approximately doubled baseline in all wells and lead baseline was exceeded in all wells, with the exception of MW-1041, during this early-year period. Two monitoring locations were slightly above baseline for both barium (MW-1035 and MW-1040) and arsenic (MW-1036 and MW-1037) during the first half-year. A potential source of the elevated metals concentration is the stainless steel casings and screens used in the construction of the detection wells. Barium, chromium, and lead can be leached from stainless steel. It is possible that such a phenomenon occurred during early 1995 when chloride levels were elevated. The leachate collection and

monitoring program at the water treatment facility indicates there are no problems with the lined impoundments.

The remainder of the monitoring parameters remained within baseline for each well. No detectable concentrations of nitroaromatic compounds, PCBs, polycyclic (or polynuclear) aromatic hydrocarbons (PAH), or pesticides were reported for 1995.

8.6 Well Abandonment

In 1995, five monitoring wells were abandoned. None of these structures were determined to required replacement for the environmental monitoring program. Table 8-26 summarizes the monitoring structures and the reason for their abandonment.

All abandonment activities were conducted in accordance with 10 CSR 23, *Missouri Well Construction Rules* and Procedure ES&H 4.4.4, *Subsurface Monitoring Device Plugging and Abandonment*. This procedure requires over-drilling of the well casing and construction material (grout, bentonite seal, and filter pack) and placing low permeability grout through the use of a tremie pipe from the bottom of the hole to the ground surface. This process maintains the integrity of the associated aquifer by eliminating any conduit from the ground surface.

TABLE 8-26 Weldon Spring Chemical Plant Wells Abandoned during 1995

LOCATION	REASON FOR ABANDONMENT
MW-2007	Preparation for Foundations Removal, 1995
MW-2011	Preparation for Foundations Removal, 1995
MW-2015	Preparation for Foundations Removal, 1995
MW-2028	Preparation for Foundations Removal, 1995
MW-2030	Preparation for Foundations Removal, 1995

Prefix:
MW = monitoring wells
LY = lysimeter

8.7 Highlights

- Elevated uranium concentration in a newly installed well (MW-4024) located east of the chemical plant eastern perimeter suggests the contaminant plume extends further toward the east than previously determined.

- Contaminant levels generally remained within historic ranges at all chemical plant locations. A new uranium high was measured at one off-site location, but subsequent uranium measurements were within historic range.

- Monitoring results for Burgermeister Spring were generally within historic ranges. Although some new highs and lows were recorded, overall, they did not represent significant changes.

- Flooding of the St. Charles County well field by the Missouri River from May until September 1995 inundated all groundwater monitoring locations in this area; nine of these wells were not sampled during the second quarter of 1995. Later sampling indicated that the St. Charles County production wells were not impacted by contaminants from the Weldon Spring Quarry area.

- Environmental monitoring indicates that the greatest amount of radiochemical and nitroaromatic contamination is still present in the bedrock of the quarry rim and the alluvial materials and bedrock north of the Femme Osage Slough.

- Slightly elevated sulfate levels at the quarry water treatment plant wells are potentially attributable to flooding around the plant. Elevated metals were detected in these wells and are believed to be due to leaching from stainless steel well construction materials.

- Total uranium concentrations remain within background ranges, and no detectable concentrations of nitroaromatic compound were identified south of the slough or in any of the St. Charles County production wells.

- Data for 1995 indicate that bulk waste removal activities have decreased the level of nitroaromatic compounds in the groundwater at the quarry.

- Trending analyses for total uranium and nitroaromatic data from both the chemical plant and the quarry area indicate stationary or downward trends overall at many locations that have exhibited stationary or upward trends in the recent past. Decreases, and at times reversal, of the groundwater flow gradient from the quarry due to dewatering activities associated with bulk waste removal are the most likely reasons contaminant levels are decreasing at the quarry.

9 BIOLOGICAL MONITORING PROGRAM

9.1 Program Description

Many of the biological sampling activities directed by DOE Orders 5400.1 and 5400.5 such as preoperational monitoring, effluent monitoring, and environmental surveillance are used to support the *National Environmental Policy Act* (NEPA) and *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) biological monitoring program and may include the collection and analysis of water, soil, foodstuffs, and biota samples.

Activities for the biological monitoring program are selected from the results of pathway analyses. Exposure pathways identified for human and ecological receptors are identified in Section 2.1 of the *Environmental Monitoring Plan* (Ref. 42). Complete pathways are those that show a link between one or more contaminant sources, through one or more environmental transport processes, to a human or ecological exposure point. These exposure pathways are used to direct biological sampling activities and determine the type of data that needs to be gathered, documented, and reported.

Results of biological monitoring also provide data for the human ingestion pathways and dose calculations to native aquatic organisms. The remaining pathways are monitored to support biological risk assessment studies and compliance with environmental surveillance requirements.

9.2 Applicable Standards

DOE Order 5400.5 addresses the protection of native aquatic organisms from the potential bioaccumulation of radionuclides. The Order states that the dose absorbed by such organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.

The biological monitoring program provides supporting data on the possible ingestion of biota by humans for the dose estimates in Section 5. These calculations were based on the guideline given in DOE Order 5400.5 that members of the public should not be exposed to radiation sources as a consequence of all routine DOE activities in any one year that could cause an annual effective dose equivalent greater than 100 mrem (1 mSv).

9.3 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the Weldon Spring site by aquatic pathways. Contaminated surface water runoff from the site to off-site lakes and streams provide the main route of exposure to biota. Studies have been conducted to determine the uptake of contaminants on biota at on-site and off-site properties. The main contaminant monitored in off-site surface water is uranium.

9.3.1 Fish

The *Environmental Monitoring Plan* (Ref. 42) requires that fish samples from the Femme Osage Slough and Busch Lakes 34, 35, and 36 be collected every other year or if annual average uranium concentrations in lake waters are found to be statistically higher than the average concentration found in lakes from previous years. In 1994, the annual average uranium concentration detected in Busch Lake 36 was statistically higher than average while the uranium averages of Lakes 34, 35, and the Femme Osage Slough remained within historical averages. Therefore, in 1995, the Weldon Spring Site Remedial Action Project (WSSRAP) and the Missouri Department of Conservation (MDC), sampled fish from Lake 36 at the Busch Memorial Conservation Area.

Samples consisted of game species such as largemouth bass, crappie, sunfish, and catfish. Samples were prepared as fillets, and were analyzed for total uranium. Uranium concentrations in fillets of fish sampled from Lake 36 in 1995 were the following: 3.3×10^{-4} Bq/g (0.009 pCi/g) in sunfish, 9.9×10^{-4} Bq/g (0.027 pCi/g) in bass, 0.001 Bq/g (< 0.032 pCi/g) in catfish, and 7.4×10^{-5} Bq/g (0.002 pCi/g) in crappie. Total uranium concentrations in fish sampled in 1995 were within historic ranges and showed no increase in uranium accumulation in fish tissues. Therefore, fish sampling in Lake 36 will return to the biennial schedule described in the *Environmental Monitoring Plan* (Ref. 42).

9.3.2 Three-Year Aquatic Surveillance Project

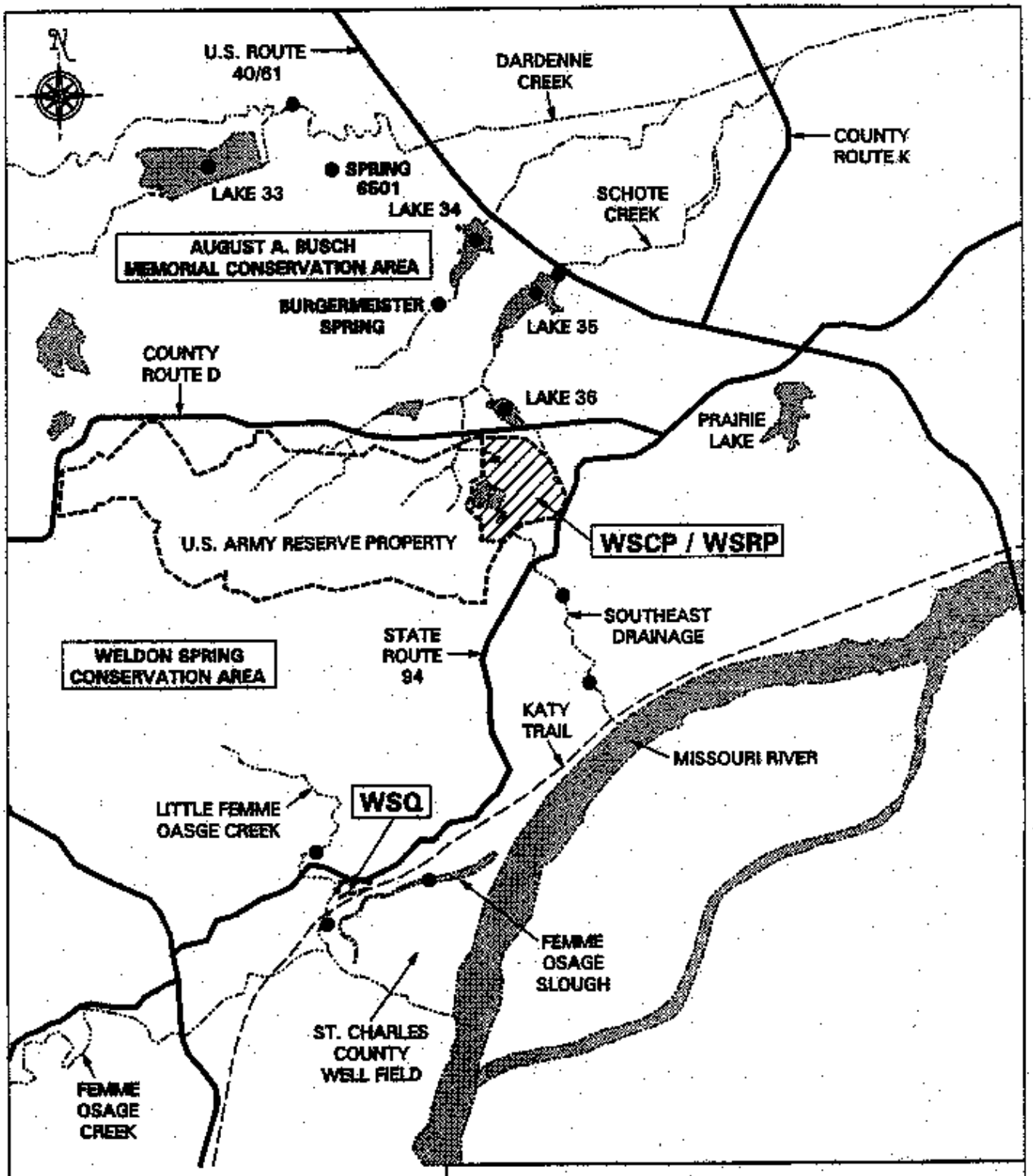
DOE Order 5400.1 requires an environmental surveillance screening program at DOE sites to determine the need for a permanent surveillance program. The purpose of the surveillance program is to monitor the effects, if any, of DOE activities on off-site

environmental and natural resources. DOE Order 5400.1 states that characterization of physical and chemical properties of the water column and sediments, as well as biological species in the water column and sediments should be conducted at DOE facilities. In addition, DOE Order 5400.5 states that the absorbed dose to native aquatic organisms shall not exceed 1 rad/day from exposure to the radioactive material in liquid wastes discharged to natural waterways. To comply with these directives, an aquatic surveillance project was conducted in 1991, 1992, and 1994 to assess the condition of waters, sediments, zooplankton and benthic invertebrates from surface waters that have received contaminated runoff from the Weldon Spring site and the Weldon Spring Quarry.

Note: This section is intended to summarize the general conclusions presented in three individual reports: *Aquatic Biological Screening Investigation* (Ref. 58), ESE-WSSRAP 1992 *Aquatic Biological Monitoring Final Report* (Ref. 59), and ESE 1994 *Aquatic Surveillance Monitoring Program Final Report* (Ref. 60). These individual reports, which present detailed descriptions of each year's sampling locations, methods, materials, and discrete data points are available upon request from the WSSRAP.

9.3.2.1 Sampling Locations. Study locations included Busch Conservation Area Lakes 34, 35, 36, Burgermeister Spring, Femme Osage Slough, Little Femme Osage Creek, Southeast Drainage, and Schote Creek. Background locations included Busch Lakes 26 and 33, Dardenne Creek, and background Spring 6501. Figure 9-1 shows sampling locations.

9.3.2.2 Surface Water. Average concentrations of uranium, alkalinity, barium, chlorophyll A, phosphorus, and total suspended solids are shown in Table 9-1. Data indicate that uranium was the primary contaminant of concern. Average uranium concentrations in water samples from the background locations (Lake 26, Lake 33, Dardenne Creek, and Background Spring) ranged from 0.0178 Bq/l to 0.067 Bq/l (0.48 to 1.8 pCi/l). Among the study lakes (Lakes 34, 35, 36, and Femme Osage Slough) average uranium concentrations in water samples ranged from 0.42 Bq/l to 1.17 Bq/l (11.4 pCi/l to 31.6 pCi/l).



AQUATIC SAMPLING LOCATIONS

FIGURE 9-1

REPORT NO.:	DOE/OR/21548-592	SUBMIT NO.:	A/VP/025/0396
ORIGINATOR:	ED	DRAWN BY:	GLN
DATE:	3/6/96		

TABLE 9-1 Average (1991-1994) Surface Water Concentrations[a]

LOCATION	ALKALINITY (mg/l)	BARIUM (µg/l)	CHLOROPHYLL A (mg/l)	PHOSPHORUS (mg/l)	TSS (mg/l)	URANIUM (pCi/l)*
Lake 26 (Background)	60.6 (43)	35.0 (45)	0.41 (46)	0.04 (45)	7.70 (48)	0.96 (42)
Lake 33 (Background)	82.2 (58)	75.3 (57)	0.03 (56)	0.07 (57)	17.2 (57)	1.82 (52)
Lake 34	101 (57)	81.3 (64)	0.33 (65)	0.06 (63)	7.19 (64)	12.8 (64)
Lake 35	58.2 (57)	51.8 (60)	1.17 (65)	0.06 (61)	6.86 (64)	11.4 (64)
Lake 36	62.6 (57)	76.4 (60)	1.55 (64)	0.06 (60)	8.22 (64)	30.2 (64)
Femme Osage Slough	148 (77)	150 (83)	3.06 (84)	0.13 (83)	51.4 (83)	31.6 (83)
Little Femme Osage Creek	241 (15)	155 (19)	0.002 (15)	0.22 (19)	26.8 (19)	1.44 (19)
Dardenne Creek (Background)	153 (12)	136 (13)	0.01 (12)	0.09 (15)	32.9 (15)	0.87 (15)
Schote Creek	144 (9)	422 (12)	0.01 (9)	0.16 (12)	31.0 (12)	3.42 (12)
Burgermeister Spring	225 (11)	141 (15)	0.0005 (8)	0.08 (15)	7.30 (15)	70.3 (15)
Southeast Drainage	31.6 (19)	111 (22)	0.0005 (19)	0.35 (22)	20.3 (22)	138 (26)
Background Spring	166 (12)	97.0 (12)	0.0005 (12)	0.09 (14)	22.20 (15)	0.48 (15)

(a) Values in parentheses indicate number of samples
* 1 pCi/l = 0.057 Bq/l

Among the study streams and springs, average uranium concentrations in water samples ranged from 1.4 pCi/l to 138.4 pCi/l.

9.3.2.3 Sediment. Average concentrations of uranium, arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and zinc are shown in Table 9-2. Average uranium concentrations in sediment samples from background locations ranged from 0.048 Bq/g (1.3 pCi/g) to 0.093 Bq/g (2.5 pCi/g). Among the study lakes, average uranium concentrations in sediment samples ranged from 0.16 Bq/g to 1.67 Bq/g (4.4 pCi/g to 45.1 pCi/g). Average uranium concentrations in sediment samples from study streams and springs ranged from 0.08 pCi/g to 1.22 pCi/g (2.2 pCi/g to 33.3 pCi/g).

9.3.2.4 Benthic Invertebrate Tissue. Average concentrations of uranium in benthic invertebrate samples are shown in Table 9-3. Average uranium concentrations in benthic invertebrate samples from background lakes and streams were typically less than 0.037 Bq/g (1.0 pCi/g). In contrast, average uranium concentrations in tissue samples from study lakes ranged from 0.063 Bq/g to 0.644 Bq/g (1.7 pCi/g to 17.4 pCi/g). Similarly, average uranium concentrations in study stream biomass samples ranged from 0.093 Bq/g to 0.755 Bq/g (2.5 pCi/g to 20.4 pCi/g).

9.3.2.5 Dose Calculation. DOE Order 5400.5 states that the guideline for dose to native aquatic organisms is 1 rad/day. Using the highest individual uranium concentration measured in these organisms (49.6 pCi/g), the absorbed dose rate to these organisms was calculated to be 0.012 rad/day which is less than the guideline dose.

9.3.2.6 Conclusions. Uranium concentrations were statistically higher in the water and sediment from study lakes than in background lakes. In addition, analysis of macroinvertebrate biomass samples revealed that uranium concentrations in biomass samples from study Lakes 34, 35, and 36 were statistically higher than biomass samples from background Lakes 26 and 33. However, correlation analysis of lake macroinvertebrate collections indicated that species richness was actually greater in those lakes which had higher uranium concentrations in the water indicating that benthic invertebrate communities have not been adversely impacted by the elevated uranium concentrations. Surface area, habitat availability, and depth are the

TABLE 9-2 Average (1991-1994) Sediment Concentrations[a]

LOCATION	ARSENIC (µg/g)	BARIUM (µg/g)	CADMIUM (µg/g)	CHROMIUM (µg/g)	LEAD (µg/g)	MERCURY (µg/g)	SELENIUM (µg/g)	SILVER (µg/g)	ZINC (µg/g)	URANIUM (pCi/g)*
Lake 26 (Background)	5.39 (15)	133 (15)	0.82 (15)	20.7 (15)	24.0 (15)	0.12 (15)	4.18 (15)	0.61 (15)	41.4 (15)	1.67 (15)
Lake 33 (Background)	4.37 (16)	162 (16)	0.80 (16)	13.9 (16)	19.6 (16)	0.09 (16)	0.79 (16)	0.47 (16)	35.6 (16)	1.34 (16)
Lake 34	5.19 (24)	167 (24)	0.95 (24)	13.0 (24)	18.5 (24)	0.07 (24)	0.65 (24)	0.48 (24)	37.0 (16)	10.4 (24)
Lake 35	4.63 (24)	188 (24)	1.02 (24)	20.6 (24)	27.1 (24)	0.05 (24)	0.84 (24)	0.42 (24)	60.3 (22)	26.6 (24)
Lake 36	5.15 (24)	129 (24)	0.93 (24)	16.7 (24)	23.2 (24)	0.05 (24)	0.66 (24)	0.58 (24)	61.9 (22)	45.1 (24)
Femme Osage Slough	8.04 (28)	228 (28)	1.16 (28)	21.0 (28)	21.9 (28)	0.11 (28)	4.12 (28)	0.47 (28)	80.5 (28)	4.36 (28)
Little Femme Osage Creek	3.05 (14)	107 (14)	0.58 (14)	6.8 (14)	7.94 (14)	0.03 (14)	0.27 (14)	0.68 (14)	31.1 (14)	2.19 (14)
Dardenne Creek (Background)	2.08 (9)	36.8 (10)	0.46 (10)	3.7 (10)	6.31 (10)	0.04 (10)	0.28 (10)	0.38 (10)	12.3 (8)	2.49 (10)
Schote Creek	4.77 (8)	112 (8)	0.57 (8)	16.6 (8)	10.8 (8)	0.04 (8)	0.33 (8)	0.43 (8)	41.1 (6)	2.62 (8)
Burgermeister Spring	5.42 (9)	83.3 (10)	0.93 (10)	14.9 (10)	20.1 (10)	0.05 (10)	0.34 (10)	0.44 (10)	50.8 (8)	33.3 (10)
Southeast Drainage	8.18 (17)	149 (15)	0.75 (15)	14.4 (15)	19.3 (21)	0.76 (21)	0.41 (15)	0.77 (19)	73.9 (17)	16.3 (19)

TABLE 9-2 Average (1991-1994) Sediment Concentrations[a] (Continued)

LOCATION	ARSENIC (µg/g)	BARIUM (µg/g)	CADMIUM (µg/g)	CHROMIUM (µg/g)	LEAD (µg/g)	MERCURY (µg/g)	SELENIUM (µg/g)	SILVER (µg/g)	ZINC (µg/g)	URANIUM (pCi/g)*
Background Spring 6501	9.73 (9)	93.6 (10)	0.60 (10)	17.9 (10)	28.5 (10)	0.04 (10)	0.26 (10)	0.59 (10)	34.3 (9)	1.62 (10)

(a) Values in parentheses indicate number of samples.
* 1 pCi = 0.037 Bq

TABLE 9-3 Average (1991-1994) Uranium Concentrations (pCi/g)[a] in Benthic Invertebrates

LOCATION	URANIUM CONCENTRATION*
Lake 26 (Background)	0.5 (7)
Lake 33 (Background)	4.25 (3)
Lake 34	1.69 (6)
Lake 35	9.07 (8)
Lake 36	17.4 (8)
Femme Osage Slough	2.11 (8)
Little Femme Osage Creek	2.53 (12)
Dardenne Creek (Background)	0.43 (3)
Schote Creek	20.4 (2)
Burgermeister Spring	12.6 (7)
Southeast Drainage	10.5 (11)
Background Spring (Background)	0.43 (5)

(a) 1 pCi = 0.037 Bq
* Values in parentheses indicate number of samples.

primary factors affecting differences between the control lakes and study lakes (Ref. 60). Overall, the lake macroinvertebrate communities appear to be dependent upon several specific physical and chemical characteristics within each lake while radiological components, although important, probably do not dramatically impact lake systems (Ref. 60).

Zooplankton communities within a lake can be impacted by numerous factors including water quality, seasonal cycles, and fish predation. Based upon analysis of zooplankton data, community composition within the Busch lakes and Femme Osage Slough appears to be most dependent upon water temperature, nutrient availability, and alkalinity (Ref. 58). Definitive conclusions based upon zooplankton data collected during the three survey periods cannot be drawn since freshwater zooplankton populations exhibit a high degree of seasonal and spacial variability from year to year. However, in reviewing analyses based strictly upon lake zooplankton characteristics (density, richness, and diversity) and lake uranium concentrations,

it does not appear that increased uranium concentrations measured from study lakes are a significant factor affecting lake zooplankton assemblages (Ref. 60).

Uranium concentrations in water and sediment were statistically higher than stream/spring sites in comparison to background sites. Although not statistically significant, it was determined that uranium concentrations in macroinvertebrate biomass samples from study sites were elevated when compared to background site samples. However, the presence of uranium within the stream and spring systems did not appear to directly influence the macroinvertebrate communities. Although increased uranium concentrations may contribute to the impairment of study sites, water flow at many of the stream sites ceases during dry periods and the resultant reduced habitat conditions may exert a more important influence on the macroinvertebrate communities (Ref. 60).

9.3.2.7 **Future Aquatic Monitoring.** Calculations using data from this study have shown that the radiation dose to native aquatic organisms in waters influenced by the Weldon Spring site (0.012 rad/day) is well within the protective guidelines (<1 rad/day) established in DOE Order 5400.5. Likewise, analysis of community structure between background and study sites did not reveal evidence of damage caused by contamination.

Therefore, unless routine surface water sampling (as outlined in the *Environmental Monitoring Plan* [Ref. 42]) reveals annual uranium averages at levels significantly higher than the average of historical uranium data from samples taken at these same locations, no further zooplankton, macroinvertebrate, or sediment sampling are required in accordance with DOE Orders 5400.1 and 5400.5.

9.3.3 Terrestrial Monitoring

The 1995 *Environmental Monitoring Plan* (Ref. 42) stipulated that the collection of agricultural products from the St. Charles County well field be analyzed for Ra-226, Ra-228, and isotopic thorium. Because of the flooded condition of the well field in late 1994 and again in early 1995, no crops were planted for the 1995 growing season. Therefore, no crop samples were available for collection during the 1995 growing season.

9.4 1995 Biological Program Highlights

- Total uranium concentrations in fish fillet samples from Busch Lake 36 remained well within the range of historical values and showed no indications of increased uranium accumulation in fish tissues.

- Unless routine surface water sampling reveals annual uranium averages at levels statistically higher than the average of historical uranium data from samples collected from the same locations, no further zooplankton, macroinvertebrate, or sediment sampling will be conducted at the locations described in Section 9.3.2.

10 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

10.1 Program Overview

The environmental quality assurance program includes management of the quality assurance/quality control programs, plans, and procedures governing environmental monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP) and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the WSSRAP and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides the WSSRAP with reliable, accurate, and precise monitoring data. The program furnishes guidance and directives to detect and prevent quality problems from the time a sample is collected until the associated data are evaluated and utilized. Key elements in achieving the goals of this program are compliance with the quality assurance program and environmental quality assurance program procedures, personnel training, compliance audits, use of quality control samples, complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness.

10.1.1 Quality Assurance Program

The *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 22) establishes the quality assurance program for activities performed by the Project Management Contractor (PMC). The QAP requires compliance with the criteria of DOE Order 5700.6C.

10.1.2 Environmental Quality Assurance Project Plan

The quality assurance requirements for WSSRAP environmental data operations are addressed in the WSSRAP *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 44). The EQAPjP outlines the appropriate requirements of EPA QA/R-5 (Ref. 65) for characterization and routine monitoring at the WSSRAP. The EQAPjP does not supersede the QAP, but rather expands on the specific requirements of environmental monitoring and characterization activities.

The primary purpose of this document is to specify the quality assurance requirements for environmental data operations of the WSSRAP. The EQAPjP is also supported by standard operating procedures (SOPs), the *Environmental Safety and Health Plan* (Ref. 45), the *Environmental Monitoring Plan* (EMP) (Ref. 42), and sampling plans written for specific environmental tasks.

10.1.3 Sample Management Guide

The *Sample Management Guide* (SMG) (Ref. 61) summarizes SOPs and data quality requirements for collecting and analyzing environmental data. The SMG describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. Guidance on developing data quality objectives for specific investigations is also detailed. The SMG details the specific requirements of the EQAPjP.

10.1.4 Environmental Monitoring and Quality Assurance Standard Operating Procedures

SOPs have been developed for routine activities at the WSSRAP. Environmental monitoring SOPs are generally administered by the Environmental Safety and Health (ES&H) Department, and Quality Assurance SOPs are administered by the Project Quality Department. These two departments are responsible for most SOPs used to administer the environmental quality assurance program described in this section. Controlled copies of SOPs are maintained in accordance with the document control requirements of the *Project Management Contractor Quality Assurance Program* (Ref. 22). SOPs should be reviewed at least annually and revised as appropriate.

10.1.5 Use and Presentation of Data

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in all reporting and calculations for this site environmental report where available. Uncensored data are those data that do not represent a ND (nondetect) and instead report instrument responses that quantitate to values below the reported detection limit. These types of data are designated by parentheses around the data value, for example "(1.17)". If

uncensored data were not available, nondetect data were used in calculations of averages at a value of one-half the detection limit (DL/2). The EPA recommends the use of the DL/2 value for statistical manipulation of data when the percentage of nondetects in the data set is small and uncensored data are not available (Ref. 46).

10.1.6 Independent Assessments and Appraisals

The environmental programs are assessed by the Project Quality Department. They evaluate compliance by performing surveillances and independent assessments of the environmental programs and generate assessment reports to track deficiencies and corrective actions. The WSSRAP is also appraised routinely by external organizations including U.S. Department of Energy (DOE) Headquarters and the DOE Oak Ridge Operations Office. The external audits assess compliance with applicable regulations, DOE Orders, and site plans and procedures. All assessment and appraisal reports, deficiencies, and corrective actions are tracked using the Site Wide Assessment Tracking System (SWATS).

10.1.7 Subcontracted Off-Site Laboratories Programs

Subcontracted off-site laboratories that performed analyses used for the preparation of this report use Contract Laboratory Program (CLP) methodologies when applicable. For certain analyses (such as radiochemical and wet chemistry) the laboratories are using EPA 600 (drinking water), EPA 900 (radiochemical analysis of drinking water), or methods that are reviewed and approved by the Project Management Contractor (PMC) prior to analysis of each sample. Each of the subcontracted off-site laboratories has submitted a site-specific *Quality Assurance Project Plan* (QAPjP) to the WSSRAP and controlled copies of their standard operating procedures. The QAPjPs and SOPs are reviewed and approved by the PMC before any samples are shipped to the laboratory. Changes to the standard analytical protocols or methodology are documented in the controlled SOPs. All of the laboratories currently being used by the WSSRAP have had a preliminary assessment of their facilities to make sure that they have the capability to perform work according to the specifications of their contracts. Quality assurance assessments are performed routinely to inspect the laboratory facilities and operations, to ensure that the laboratories are performing analyses as specified in their contracts, and to check that WSSRAP data documentation and records are being properly maintained.

10.2 Applicable Standards

Applicable standards for environmental quality assurance include: (1) use of the appropriate analytical and field measurement methodologies; (2) collection and evaluation of quality control samples; (3) accuracy, precision, and completeness evaluations; and (4) preservation and security of all applicable documents and records pertinent to the environmental monitoring programs.

10.2.1 Analytical and Field Measurement Methodologies

Analytical and field measurement methodologies used at the WSSRAP comply with applicable standards required by the DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring follow the EPA CLP requirements (metal and organic methodologies) and the EPA drinking water and radiochemical methodologies or methods that are reviewed and approved by the PMC prior to analysis of each sample. Field measurement methodologies typically follow the American Public Health Association *Standard Methodologies for the Examination of Water and Wastewater* (Ref. 47).

10.2.2 Quality Control Samples

Quality control samples for environmental monitoring are collected in accordance with WSSRAP SOPs that specify the frequencies of quality control sample collection. Quality control samples are taken in accordance with guidelines in the EPA CLP (Ref. 29).

Descriptions of the QC samples collected at the WSSRAP are detailed in Table 10-1.

TABLE 10-1 QC Sample Description

TYPE OF BLANK	DESCRIPTION
Water Blank (WB)	Monitors the purity of distilled water used for field blanks and decontamination of sampling equipment. Water blanks are collected directly from the distilled water reservoir in the WSSRAP laboratory.
Field Blank (FB)	Monitors potential contaminants, such as dust or volatile compounds, that may be introduced at the site of sample collection. Field blanks are collected in the field at the same time of sample collection activities.
Equipment Blank (EB)	Monitors the effectiveness of decontamination procedures used on non-dedicated sampling equipment. Equipment blanks include rinsate and filter blanks.
Trip Blank (TB)	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory. Trip blanks shall be collected in the WSSRAP laboratory with prepurged distilled water.
Field Replicate (FR)	Monitors field conditions that may affect the reproducibility of samples collected from a given location. Field replicates are collected in the field at the sample location.
Blind Duplicate	A duplicate that provides an unbiased measure of laboratory precision. Blind duplicates are additional aliquots of the routine sample taken in the field and given an altered identification code to conceal the samples identity from the laboratory.
Matrix Spike* (MS)	Assesses matrix and accuracy of laboratory measurements for a given matrix type. The results of this analysis and the routine sample are used to compute the percent recovery for each parameter.
Matrix Duplicate* (DU)	Assesses matrix and precision of laboratory measurements for inorganic parameters in a given matrix type. The results of the matrix duplicate and the routine sample are used to compute the relative percent difference for each parameter.
Matrix Spike Duplicate* (MD)	Assesses matrix and precision of laboratory measurements for organic compounds. The matrix spike duplicate is spiked in the same manner as the matrix spike sample. The results of the matrix spike and matrix spike duplicate are used to determine the relative percent difference for organic parameters.

TABLE 10-1 QC Sample Description (Continued)

TYPE OF BLANK	DESCRIPTION
Secondary Duplicate (SD)	A duplicate that compares the primary laboratory with a secondary laboratory, providing an additional check on the performance of the primary laboratory. The secondary duplicate is an additional aliquot of the routine sample that is sent to a secondary laboratory.

* A laboratory sample is split from large volume samples.

10.2.3 Accuracy, Precision, and Completeness

At a minimum, the WSSRAP Data Validation Group determines the analytical accuracy, precision, and completeness of 10% of the environmental data collected. Data validation is required under DOE Order 5400.1.

10.2.4 Preservation and Security of Documents and Records

Requirements for preservation and security of documents and records are specified in DOE Order 5700.6C. All documents pertinent to environmental monitoring are preserved and secured by the departments that produce them.

10.3 Quality Assurance Sample Results

The quality assurance program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

10.3.1 Duplicate Analyses Results

Two kinds of duplicate analyses were performed in 1995, matrix duplicates and secondary duplicates. The matrix duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring site. A secondary duplicate is an additional aliquot of the original sample split by the WSSRAP and placed into a separate container and sent to a secondary laboratory. Matrix duplicates were used to assess

the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interferences of sample matrixes.

Generally, matrix duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one for every 20 samples. Secondary duplicate samples were collected in accordance with Procedure ES&H 4.1.4, which states that secondary duplicates shall be collected on a monthly basis. Typically, duplicate samples were analyzed for more common parameters e.g., uranium, nitroaromatic compounds, inorganic anions, and metals.

When matrix and secondary duplicate samples were available, the average relative percent difference was calculated. This difference represents an estimate of precision. The equation used (as specified in the *USEPA Contract Laboratory Program, Inorganic Scope of Work*, [Ref. 29]) was:

$$RPD = (S-D)/((S+D)/2) \times 100$$

where S = the normal sample
D = the duplicate analysis

The relative percent difference was calculated only for samples whose analytical results exceeded five times the detection limit.

Table 10-2 summarizes the data of calculated relative percent differences for groundwater (including springs) and surface water (including National Pollutant Discharge Elimination System [NPDES]) samples for the parameters of sufficient data size to permit averaging. Both the

TABLE 10-2 Summary of Calculated Relative Percent Differences

PARAMETER	GROUNDWATER [a] DUPLICATES		SURFACE WATER[b] DUPLICATES	
	RPD%(c)	COUNT NO.(e)	RPD%(c)	COUNT NO.(e)
Alkalinity	3.43	19	(d)	0
Chloride	1.32	9	1.90	18
Fluoride	(d)	0	6.30	11
Nitrate-N	3.98	15	3.19	10
Sulfate	2.56	14	1.53	18
Calcium	3.32	19	(d)	0
Barium	2.45	26	(d)	0
Strontium	2.56	4	(d)	0
Lithium	1.96	8	(d)	0
Arsenic	6.08	5	(d)	0
Chromium	5.66	3	(d)	0
Lead	2.90	5	(d)	0
Uranium, Total	12.91	24	7.50	22

(a) Groundwater samples include spring samples.
(b) Surface water samples include NPDES samples.
(c) RPD = average relative percent difference.
(d) Average RPD could not be calculated for these parameters.
(e) RPD sample population for each parameter.

matrix duplicates and the secondary duplicates are summarized together. Parameters that were not commonly analyzed for an/or were not contaminants of concern were not evaluated.

The results in Table 10-2 demonstrate that all average relative percent differences calculated were within the 20% criterion as recommended in the CLP (Ref. 29 and 46). As a result duplicate samples analyses in 1995 were of acceptable quality.

10.3.2 Blank Sample Results Evaluation

Various types of blanks are collected by the WSSRAP to assess the conditions and/or contaminants that may be present during sample collection and transportation. These conditions and contaminants are monitored by collecting samples to ensure routine samples are not being contaminated. Blank samples evaluate the:

- Environmental conditions under which the samples (i.e., volatile analyses) were shipped (trip blanks).
- Ambient conditions in the field that may effect a sample during collection (field/trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).
- Quality of water used to decontaminate sampling equipment and/or assess the ambient conditions (distilled water blanks).
- Presence or absence of contamination potentially introduced through sample preservation and/or sample containers.

Sections 10.3.2.1 through 10.3.2.4 discuss the sample blank analyses and the summary of analytical results that were above the analytical detection limits. Field blank samples for groundwater, surface water, spring and seep water, and NPDES water were evaluated together as a set.

10.3.2.1 Trip Blank Evaluation. Trip blanks are collected to assess the impact of sample collection and shipment on groundwater and surface water samples analyzed for volatile organic compounds. Trip blanks are sent to the laboratory with each shipment of volatile organic samples.

In 1995, five trip blanks were analyzed for volatile organic compounds. A low concentration of acetone was detected in one sample. The acetone concentration found in this sample was just above the detection limit and did not exceed the CLP criterion.

10.3.2.2 Field Blank Evaluation. Field blank samples are collected at monitoring sites just prior to, or immediately after, actual samples are collected. The field blanks are collected to assess the ambient air conditions at the sample locations. They are analyzed for the parameters being sampled which, therefore, are generally the parameters of concern, such as uranium, anions, metals, and nitroaromatics.

In 1995, four field blanks were collected. Table 10-3 presents the ratio of detects to total number of samples collected for each parameter having results above the detection limits. All of the contaminants found were low level (less than five times the detection limit); therefore, there is no impact on routine samples.

10.3.2.3 Equipment and Bailer Blank Evaluation. Equipment and bailer blanks are collected by rinsing decontaminated equipment and bailers with distilled water, and collecting the rinse water. This procedure is used to determine the effectiveness of the decontamination process. At the WSSRAP, most of the groundwater samples are collected from dedicated equipment, and surface water is collected by placing the sample directly into a sample container; therefore, no further discussion is presented.

10.3.2.4 Distilled Water Blank Evaluation. Water blank samples are collected to evaluate the quality of the distilled water used to decontaminate sampling equipment and to assess whether contaminants are present in the water used for field and trip blanks. Water blank samples also serve as laboratory blanks. Generally, the water blanks were analyzed for contaminants of concern and were collected at the same time as field blanks. In 1995, nine water blanks were collected. Table 10-4 presents the ratio of detects to the total number of samples collected for each parameter that had results above the detection limit.

TABLE 10-3 Summary of Field Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF ANALYSES	EVALUATION AND SUMMARY OF DETECTS
Nitroaromatics	0 out of 4 (0%)	N/A
Chloride	0 out of 2 (0%)	N/A
Nitrate-N	1 out of 3 (34%)	1 of 1 (100%) <2xDL
Sulfate	0 out of 3 (0%)	N/A
Uranium, Total	0 out of 4 (0%)	N/A
Arsenic	0 out of 2 (0%)	N/A
Barium	0 out of 2 (0%)	N/A
Beryllium	0 out of 2 (0%)	N/A
Cadmium	0 out of 2 (0%)	N/A
Chromium	0 out of 2 (0%)	N/A
Lead	0 out of 2 (0%)	N/A
Lithium	0 out of 1 (0%)	N/A
Mercury	0 out of 2 (0%)	N/A
Selenium	0 out of 2 (0%)	N/A
Strontium	0 out of 2 (0%)	N/A
Thallium	1 out of 2 (50%)	1 of 1 (100%) 2xDL

DL Detection limit; <2x = Less than two times; 2 x = two times
N/A Not applicable

TABLE 10-4 Summary of Distilled Water Blank Parameter Results

PARAMETER	NUMBER OF DETECTS/NUMBER OF ANALYSES	EVALUATION AND SUMMARY OF DETECTS
Nitroaromatics	0 out of 9 (0%)	N/A
Chloride	0 out of 4 (0%)	N/A
Nitrate-N	1 out of 8 (13%)	1 of 1 (100%) <2xDL
Sulfate	0 out of 8 (0%)	N/A
Uranium, Total	3 out of 8 (38%)	2 of 2 (100%) <5xDL 1 of 1 (100%) <5xDL
Arsenic	0 out of 6 (0%)	N/A
Barium	1 out of 6 (17%)	1 of 1 (100%) >5xDL
Beryllium	0 out of 6 (0%)	N/A
Cadmium	0 out of 6 (0%)	N/A
Chromium	2 out of 6 (34%)	2 of 2 (100%) <2xDL
Lead	0 out of 6 (0%)	N/A
Lithium	0 out of 5 (0%)	N/A
Mercury	0 out of 6 (0%)	N/A
Selenium	0 out of 6 (0%)	N/A
Strontium	0 out of 5 (0%)	N/A
Thallium	0 out of 6 (0%)	N/A

DL = Detection limit; <2x = Less than two times; <5x = less than five times; >5x = Greater than five times
N/A = Not applicable

10.4 1995 Data Validation Program Summary

Data validation programs at the WSSRAP involve reviewing and qualifying at least 10% of the data collected during a calendar year. The information summarized below applies to all WSSRAP data collected and is not limited to environmental monitoring data. The data points

represent the number of parameters analyzed (e.g., toluene), not the number of physical analyses performed (e.g., volatile organics analyses).

Table 10-5 identifies the number of quarterly and total data points that were selected for data validation, and indicates the percentage of those selected that were completed. Data points presented in this table include all sample types.

Table 10-6 identifies validation qualifiers assigned to the selected data points as a result of data validation. The WSSRAP validation technical review was performed in accordance with the *U.S. EPA Contract Laboratory Program Data Statement of Work for Inorganics Analysis* (Ref. 62), the *U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis* (Ref. 63), and the *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analysis* (Ref. 64). To date, 98.6% of data validation has been completed. Data points presented in this table include water sample types only.

Table 10-7 identifies the average accuracy and precision for all sample types including environmental and waste management samples for anion, metal, nitroaromatic, radiochemical, and miscellaneous parameters. The accuracy values are based on the percent recoveries of the laboratory control samples, and the precision values are based on the relative percent difference between duplicates. The data population size associated with each accuracy and precision value is listed as "n." Data points presented in this table include water sample types only.

10.5 Interlaboratory Comparison Program Results

This section summarizes the interlaboratory comparison program data received from the subcontracted laboratories. Data presented in this section are from three programs: (1) the DOE quality assessment program, (2) the EPA intercomparison radionuclide control program and (3) the EPA organic and inorganic performance evaluation studies.

The interlaboratory comparison programs are intended to allow participating laboratories to analyze spiked control samples to verify and evaluate how their standard operating procedures (SOPs) and quality assurance and quality control (QA/QC) programs are performing.

TABLE 10-5 WSSRAP Validation Summary for Calendar Year 1995

CALENDAR QUARTER	NO. OF DATA POINTS COLLECTED	NO. OF DATA POINTS SELECTED FOR VALIDATION	PERCENT SELECTED	NO. OF DATA POINTS VALIDATED	PERCENT VALIDATED
Quarter 1	7,058	614	8.7%	614	100.0%
Quarter 2	14,300	1,463	10.2%	1,463	100.0%
Quarter 3	20,414	2,187	10.7%	2,187	100.0%
Quarter 4	12,215	1,257	10.3%	1,182	94.0%
1995 Total	53,987	5,521	10.2%	5,446	98.6%

TABLE 10-6 Annual Data Validation Qualifier Summary for Calendar Year 1995

NO. OF DATA POINTS										
	ANIONS	METALS	MISCELLANEOUS	NITROAROMATICS	PEST/PCBs	RADIOCHEMICAL	SEMI-VOA	VOA	HERBICIDES	TOTAL
Accepted	207	2,242	80	349	372	986	724	345	2	5,307
Rejected	9	29	1	90		6		4		139
On Hold										0
Not Validatable										0
Pending	6	8	2			59				75
Total	222	2,279	83	439	372	1,051	724	349	2	5,521
Percentages										
Accepted	93.2%	98.4%	96.4%	79.5%	100.0%	93.8%	100.0%	98.9%	100.0%	96.1%
Rejected	4.1%	1.3%	1.2%	20.5%	0.0%	0.6%	0.0%	1.1%	0.0%	2.5%
On Hold	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Not Validatable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pending	2.7%	0.4%	2.4%	0.0%	0.0%	5.6%	0.0%	0.0%	0.0%	1.4%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1995

	LABORATORY ACCURACY		LABORATORY PRECISION	
PARAMETER	AVERAGE (% REC.)	n	AVERAGE (RPD)	n
ANIONS				
Chloride	98.0	44	1.2	43
Fluoride	97.2	47	2.6	47
Nitrate-N	100.5	71	0.8	68
Sulfate	98.6	48	1.2	48
METALS				
Aluminum	93.5	79	5.4	76
Antimony	98.3	79	2.4	76
Arsenic	97.0	139	2.1	136
Barium	95.9	83	2.3	80
Beryllium	101.0	79	2.0	76
Cadmium	102.9	84	1.3	81
Calcium	106.5	69	1.9	72
Chromium	100.0	119	2.0	116
Cobalt	97.4	79	1.7	76
Copper	99.3	81	2.1	78
Iron	101.2	79	3.2	76
Lead	97.4	137	2.1	134
Lithium	99.8	73	2.2	76
Magnesium	100.6	69	3.1	72
Manganese	97.3	95	2.1	92
Mercury	98.6	98	2.2	95
Molybdenum	95.7	76	1.5	76
Nickel	98.0	79	10.2	76

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1995 (Continued)

	LABORATORY ACCURACY		LABORATORY PRECISION	
PARAMETER	AVERAGE (% REC.)	n	AVERAGE (RPD)	n
Potassium	98.4	75	4.2	66
Selenium	98.0	99	2.8	96
Silver	95.4	84	2.0	81
Sodium	97.5	69	2.1	72
Thallium	95.7	107	2.7	103
Vanadium	96.8	79	1.3	76
Zinc	100.9	82	1.1	79
MISCELLANEOUS				
Alkalinity	88.5	5	20.0	3
Chemical Oxygen Demand	98.6	16	3.0	10
Cyanide, Amenable	93.2	12	4.7	12
Total Suspended Solids	97.4	14	1.9	12
NITROAROMATICS				
1,3,5-Trinitrobenzene	63.6	69	30.2	45
1,3-Dinitrobenzene	99.2	69	8.0	45
2,4,6-TNT	58.5	72	44.4	46
2,4-DNT	101.7	88	4.4	56
2,6-DNT	101.9	69	1.5	45
Nitrobenzene	96.0	69	3.8	45
PESTICIDES/PCBS				
Aroclor-1016	112.9	21	2.5	6
Aroclor-1221	112.9	21	2.5	6
Aroclor-1232	112.9	21	2.5	6

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1995 (Continued)

	LABORATORY ACCURACY		LABORATORY PRECISION	
PARAMETER	**AVERAGE (% REC.)**	**n**	**AVERAGE (RPD)**	**n**
Aroclor-1242	112.9	21	2.5	6
Aroclor-1248	108.5	25	3.7	7
Aroclor-1254	108.6	35	2.5	6
Aroclor-1260	112.3	23	2.5	6
RADIOCHEMICAL				
Gross Alpha	99.1	23	12.1	23
Gross Beta	98.1	10	4.0	10
Lead-210	137.1	1	10.1	1
Ra-226	89.7	76	10.0	29
Ra-228	85.7	76	12.3	29
Th-228	100.5	88	11.2	17
Th-230	102.1	133	16.5	64
Th-232	100.7	88	10.3	19
Uranium, Total	100.7	145	4.4	135
Uranium-234	105.7	47	7.4	17
Uranium-235	102.4	34	0.7	4
Uranium-238	96.4	187	6.9	123
SEMI-VOLATILES				
1,2,4-Trichlorobenzene	69.9	9	9.0	6
1,4-Dichlorobenzene	65.8	9	9.0	6
2,4-Dinitrotoluene	80.7	9	9.0	6
2-Chlorophenol	75.6	3	---	0
4-Chloro-3-Methyl Phenol	94.9	3	---	0

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1995 (Continued)

	LABORATORY ACCURACY		LABORATORY PRECISION	
PARAMETER	AVERAGE (% REC.)	n	AVERAGE (RPD)	n
4-Nitrophenol	89.5	3	---	0
Acenaphthene	77.1	30	20.1	18
Acenaphthylene	90.0	18	5.2	18
Anthracene	90.4	18	4.7	18
Benzo(a)Anthracene	84.8	22	7.0	22
Benzo(a)Pyrene	87.8	22	5.8	22
Benzo(b)Fluoranthene	90.4	22	5.2	22
Benzo(g,h,i)Perylene	82.8	18	5.5	18
Benzo(k)Fluoranthene	89.0	22	6.2	22
Chrysene	93.0	22	5.7	22
Dibenzo(a,h)Anthracene	62.5	18	9.9	18
Fluoranthene	94.0	18	6.0	18
Fluorene	88.5	18	4.7	18
Indeno(1,2,3-cd)Pyrene	79.9	22	5.6	22
N-Nitroso-di-n-Propylamine	77.7	9	9.0	6
Naphthalene	96.1	18	7.3	18
Pentachlorophenol	75.1	3	---	0
Phenanthrene	90.6	18	5.3	18
Phenol	76.0	3	---	0
Pyrene	93.1	30	9.4	18
VOLATILES				
1,1-Dichloroethene	99.1	6	---	0
Benzene	106.2	6	---	0

TABLE 10-7 Laboratory Accuracy and Precision Summary for Calendar Year 1995 (Continued)

	LABORATORY ACCURACY		LABORATORY PRECISION	
PARAMETER	AVERAGE (% REC.)	n	AVERAGE (RPD)	n
Chlorobenzene	115.1	6	---	0
Toluene	109.9	6	---	0
Trichloroethene	111.9	6	---	0

Interlaboratory comparison program results presented in this section do not impact any of the analytical data used to prepare this report, but are discussed here to provide information about laboratories' capabilities to perform accurate analyses of spiked control samples.

Results of the DOE environmental measurement laboratory quality assessment program are presented in Table 10-8. This table provides information on the parameter, matrix type, laboratory name, DOE value, reported value, percent recovery, and performance criteria evaluation.

Results of the EPA intercomparison radionuclide control program are presented in Table 10-9. This table provides information on the parameter, matrix type, laboratory name, date analyzed, EPA value, reported value, percent recovery, and control limit evaluation.

Results of the EPA organic and inorganic performance evaluation program are not presented in this section. However, this information is evaluated during the routine assessments of each laboratory. Results of the 1995 performance evaluation samples have been reviewed, and no major problems with the results from these programs were observed.

TABLE 10-8 Summary of the DOE Interlaboratory Comparison Program

PARAMETER (MATRIX)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION (a)
Uranium,234 (soil)	ACCU-Labs	30.300	23.000	76%	A
Uranium,238 (soil)	ACCU-Labs	31.600	21.900	69%	W
Uranium,total (soil)	ACCU-Labs	2.500	2.130	85%	A
Uranium,total (soil)	ACCU-Labs	2.460	1.560	63%	A
Uranium,234 (water)	ACCU-Labs	0.373	0.376	101%	A
Uranium,total (water)	ACCU-Labs	0.003	0.003	113%	A
Gross alpha (water)	ACCU-Labs	1340.000	1400.000	104%	A
Gross beta (water)	ACCU-Labs	2.690	2.300	86%	A
Uranium,234 (air)	Barringer	0.059	0.030	51%	N
Uranium,234 (air)	Barringer	0.052	0.081	157%	W
Uranium,238 (air)	Barringer	0.002	0.029	1450%	N
Uranium,238 (air)	Barringer	0.053	0.081	152%	W
Uranium,total (air)	Barringer	0.538	2.370	441%	N
Uranium,total (air)	Barringer	4.300	6.570	153%	W
Uranium,234 (soil)	Barringer	30.300	30.500	100%	A
Uranium,234 (soil)	Barringer	30.300	32.400	107%	A
Uranium,234 (soil)	Barringer	29.500	24.600	83%	A
Uranium,238 (soil)	Barringer	31.600	29.800	94%	A
Uranium,238 (soil)	Barringer	31.600	31.600	100%	A
Uranium,238 (soil)	Barringer	30.400	24.600	81%	A
Uranium,total (soil)	Barringer	2.500	2.460	98%	A
Uranium,total (soil)	Barringer	2.500	2.610	104%	A
Uranium,total (soil)	Barringer	2.460	1.990	81%	A
Uranium,234 (water)	Barringer	0.306	0.370	121%	W
Uranium,234 (water)	Barringer	0.306	0.380	124%	W
Uranium,238 (water)	Barringer	0.311	0.380	122%	W
Uranium,238 (water)	Barringer	0.311	0.370	119%	W

TABLE 10-8 Summary of the DOE Interlaboratory Comparison Program (Continued)

PARAMETER (MATRIX)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION [a]
Uranium,total (water)	Barringer	0.025	0.030	118%	W
Uranium,total (water)	Barringer	0.025	0.030	120%	W
Uranium,234 (soil)	ES&E	29.500	21.800	74%	A
Uranium,234 (soil)	ES&E	30.300	26.500	88%	A
Uranium,238 (soil)	ES&E	30.400	21.200	70%	A
Uranium,238 (soil)	ES&E	31.600	22.600	72%	A
Uranium,total (soil)	ES&E	2.460	2.560	104%	A
Uranium,total (soil)	ES&E	2.500	2.260	90%	A
Uranium,234 (water)	ES&E	0.306	0.354	116%	A
Uranium,234 (water)	ES&E	0.373	0.340	91%	A
Uranium,238 (water)	ES&E	0.311	0.324	104%	A
Uranium,total (water)	ES&E	0.025	0.029	117%	W
Uranium,total (water)	ES&E	0.003	0.003	98%	A
Gross alpha (water)	ES&E	1310.000	793.000	61%	W
Gross alpha (water)	ES&E	1340.000	1460.000	109%	A
Gross beta (water)	ES&E	410.000	440.000	107%	A
Gross beta (water)	ES&E	653.000	843.000	129%	W
Uranium,total (soil)	Ecotek	2.500	1.970	79%	A
Uranium,total (water)	Ecotek	0.003	0.003	105%	A
Gross alpha (water)	Ecotek	1340.000	1320.000	99%	A
Gross beta (water)	Ecotek	653.000	642.000	98%	A
Uranium,234 (soil)	General	30.300	27.500	91%	A
Uranium,234 (soil)	General	29.500	30.800	104%	A
Uranium,238 (soil)	General	31.600	26.600	84%	A
Uranium,238 (soil)	General	30.400	30.200	99%	A
Uranium,234 (water)	General	0.373	0.300	80%	W
Uranium,234 (water)	General	0.306	0.345	113%	A

TABLE 10-8 Summary of the DOE Interlaboratory Comparison Program (Continued)

PARAMETER (MATRIX)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION
Uranium,238 (water)	General	0.311	0.339	109%	A
Uranium,total (water)	General	0.003	0.005	173%	N
Gross alpha (water)	General	1340.000	1750.000	131%	W
Gross alpha (water)	General	1310.000	1210.000	92%	A
Gross beta (water)	General	653.000	898.000	138%	W
Gross beta (water)	General	410.000	426.000	104%	A
Uranium,234 (water)	Heritage	0.373	0.310	83%	W
Uranium,234 (soil)	IEA	30.300	25.600	85%	A
Uranium,238 (soil)	IEA	31.600	24.500	78%	A
Uranium,234 (water)	IEA	0.373	0.425	114%	A
Gross alpha (water)	IEA	1340.000	1510.000	113%	A
Gross beta (water)	IEA	653.000	645.000	99%	A
Uranium,234 (soil)	Lockheed	30.300	24.300	80%	A
Uranium,234 (soil)	Lockheed	29.500	25.000	85%	A
Uranium,238 (soil)	Lockheed	31.600	25.000	79%	A
Uranium,238 (soil)	Lockheed	30.400	26.000	86%	A
Uranium,total (soil)	Lockheed	2.690	2.500	93%	A
Uranium,234 (water)	Lockheed	0.373	0.491	132%	W
Uranium,234 (water)	Lockheed	0.306	0.400	131%	W
Uranium,238 (water)	Lockheed	0.311	0.380	122%	W
Gross alpha (water)	Lockheed	1340.000	1080.000	81%	A
Gross alpha (water)	Lockheed	1310.000	957.000	73%	W
Gross beta (water)	Lockheed	653.000	601.000	92%	A
Gross beta (water)	Lockheed	410.000	373.000	91%	W
Uranium,234 (soil)	TMA/Norcal	30.300	26.000	86%	A
Uranium,238 (soil)	TMA/Norcal	31.600	26.300	83%	A
Uranium,238 (soil)	TMA/Norcal	30.400	23.300	77%	A

TABLE 10-8 Summary of the DOE Interlaboratory Comparison Program (Continued)

PARAMETER (MATRIX)	LABORATORY	DOE VALUE	REPORTED VALUE	PERCENT RECOVERY	EVALUATION [a]
Uranium,total (soil)	TMA/Norcal	2.460	1.380	56%	A
Uranium,234 (water)	TMA/Norcal	0.373	0.385	103%	A
Uranium,234 (water)	TMA/Norcal	0.306	0.347	113%	A
Uranium,238 (water)	TMA/Norcal	0.311	0.349	112%	W
Gross alpha (water)	TMA/Norcal	1340.000	1480.000	110%	A
Gross alpha (water)	TMA/Norcal	1310.000	1090.000	83%	W
Gross beta (water)	TMA/Norcal	653.000	671.000	103%	A
Gross beta (water)	TMA/Norcal	410.000	379.000	92%	W
Uranium,234 (soil)	TMA/OR	30.300	25.800	85%	A
Uranium,238 (soil)	TMA/OR	31.600	22.300	71%	A
Uranium,total (soil)	TMA/OR	2.460	2.700	110%	A
Uranium,234 (water)	TMA/OR	0.373	0.370	99%	A
Uranium,total (water)	TMA/OR	0.025	0.028	112%	A
Gross alpha (water)	TMA/OR	1340.000	1310.000	98%	A
Gross alpha (water)	TMA/OR	1310.000	1210.000	92%	A
Gross beta (water)	TMA/OR	653.000	912.000	140%	W
Gross beta (water)	TMA/OR	410.000	728.000	178%	N

(a) A Acceptable
W Acceptable with warning
N Not acceptable

Units for matrices: Air Bq/filter
Soil Bq/kg
Water Bq/l

TABLE 10-9 Summary of EPA - EMSL Interlaboratory Radionuclide Control Program

PARAMETER (MATRIX)	LABORATORY (DATE)	EPA EMSL VALUE	AVERAGE REPORTED VALUE	PERCENT RECOVERY	EPA* TAG
Gross Alpha (water)	Accu-lab 01/95	5.0	5.7	114%	
Gross Alpha (water)	Accu-lab 07/95	27.5	28.7	104%	
Gross Beta (water)	Accu-lab 01/95	5.0	6.3	126%	
Gross Beta (water)	Accu-lab 07/95	19.4	23.3	120%	
Radium-226 (water)	Accu-lab 02/95	19.3	20.2	106%	
Radium-226 (water)	Accu-lab 06/95	14.8	16.5	111%	
Radium-226 (water)	Accu-lab 09/95	24.8	25.9	104%	
Radium-228 (water)	Accu-lab 02/95	20.0	14.4	72%	
Radium-228 (water)	Accu-lab 06/95	15.0	14.0	93%	
Radium-228 (water)	Accu-lab 09/95	20.0	14.2	71%	
Uranium,total (water)	Accu-lab 02/95	25.5	20.8	82%	
Uranium,total (water)	Accu-lab 06/95	15.2	15.7	103%	
Uranium,total (water)	Accu-lab 09/95	30.5	30.8	101%	
Gross Alpha (air)	Accu-lab 08/95	25.0	31.0	124%	
Gross Beta (air)	Accu-lab 08/95	86.6	86.3	100%	
Gross Alpha (water)	ES&E 07/95	27.5	14.0	51%	↓
Gross Beta (water)	ES&E 07/95	19.4	24.7	79%	
Uranium,total (water)	ES&E 02/95	19.1	40.1	209%	↑
Uranium,total (water)	ES&E 06/95	15.2	15.8	104%	
Radium-226 (water)	ES&E 06/95	14.8	10.3	70%	↓
Radium-228 (water)	ES&E 02/95	20.0	35.0	175%	↑
Radium-228 (water)	ES&E 06/95	15.0	9.7	65%	
Gross Alpha (water)	IEA 01/95	5.0	3.7	73%	
Gross Beta (water)	IEA 01/95	5.0	2.0	40%	

TABLE 10-9 Summary of EPA - EMSL Intercomparison Radionuclide Control Program (Continued)

PARAMETER (MATRIX)	LABORATORY (DATE)	EPA EMSL VALUE	AVERAGE REPORTED VALUE	PERCENT RECOVERY	EPA* TAG
Radium-226 (water)	IEA 02/95	25.5	24.1	95%	
Radium-226 (water)	IEA 06/95	14.8	15.2	103%	
Radium-228 (water)	IEA 02/95	20.0	37.9	189%	†
Radium-228 (water)	IEA 06/95	15.0	14.5	96%	
Uranium,total (water)	IEA 02/95	25.5	23.3	91%	
Uranium,total (water)	IEA 06/95	15.2	13.0	86%	
Gross Alpha (water)	TMA/OR 01/95	5.0	4.7	94%	
Gross Alpha (water)	TMA/OR 07/95	25.5	23.0	90%	
Gross Alpha (water)	TMA/OR 10/95	51.2	25.8	50%	↓
Gross Beta (water)	TMA/OR 01/95	5.0	4.0	80%	
Gross Beta (water)	TMA/OR 07/95	19.4	14.0	72%	
Gross Beta (water)	TMA/OR 10/95	24.8	16.6	67%	
Uranium,total (water)	TMA/OR 02/95	25.5	24.1	95%	
Uranium,total (water)	TMA/OR 06/95	15.2	13.2	87%	
Uranium,total (water)	TMA/OR 09/95	30.5	29.8	98%	
Radium-226 (water)	TMA/OR 02/95	19.1	16.9	88%	
Radium-226 (water)	TMA/OR 06/95	14.8	12.0	81%	
Radium-226 (water)	TMA/OR 09/95	24.8	23.3	94%	
Radium-228 (water)	TMA/OR 02/95	20.0	18.8	94%	
Radium-228 (water)	TMA/OR 06/95	15.0	15.2	101%	
Radium-228 (water)	TMA/OR 06/95	15.0	15.2	101%	
Radium-228 (water)	TMA/OR 09/95	20.0	20.6	103%	
Gross Alpha (air)	TMA/OR 08/95	25.0	26.2	105%	
Gross Beta (air)	TMA/OR 08/95	86.6	83.5	96%	

TABLE 10-9 Summary of EPA - EMSL Intercomparison Radionuclide Control Program (Continued)

PARAMETER (MATRIX)	LABORATORY (DATE)	EPA EMSL VALUE	AVERAGE REPORTED VALUE	PERCENT RECOVERY	EPA* TAG
Gross Alpha (water)	Quanterra 01/95	5.0	5.0	100%	
Gross Alpha (water)	Quanterra 07/95	27.5	23.5	86%	
Gross Beta (water)	Quanterra 01/95	5.0	5.0	100%	
Gross Beta (water)	Quanterra 07/95	19.4	17.9	92%	
Uranium,total (water)	Quanterra 02/95	25.5	24.6	96%	
Uranium,total (water)	Quanterra 06/95	15.2	14.6	96%	
Radium-226 (water)	Quanterra 02/95	19.1	15.7	82%	
Radium-226 (water)	Quanterra 06/95	14.8	8.93	60%	
Radium-228 (water)	Quanterra 02/95	20.0	18.3	91%	
Radium-228 (water)	Quanterra 06/95	15.0	17.6	117%	
Uranium,total (water)	Quanterra 06/95	15.2	14.6	96%	
Radium-226 (water)	Quanterra 02/95	19.1	15.7	82%	
Radium-226 (water)	Quanterra 06/95	14.8	8.93	60%	
Radium-228 (water)	Quanterra 02/95	20.0	18.3	91%	
Radium-228 (water)	Quanterra 06/95	15.0	17.6	117%	

* EPA control limits are based on three normalized standard deviations above and below the known value.
↑ Above the EPA control limit
↓ Below the EPA control limit
Note: EMSL = Environmental Measurements and Standards Laboratory

11 SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project that support and assist in the implementation of environmental protection policies. In addition, short term environmental studies are described that support regulatory requirements not specifically covered by U.S. Department of Energy (DOE) Order 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 42).

11.1 Special Studies

The special studies described in this subsection are short-term or one-time studies that support regulatory requirements not specifically covered by DOE 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 42).

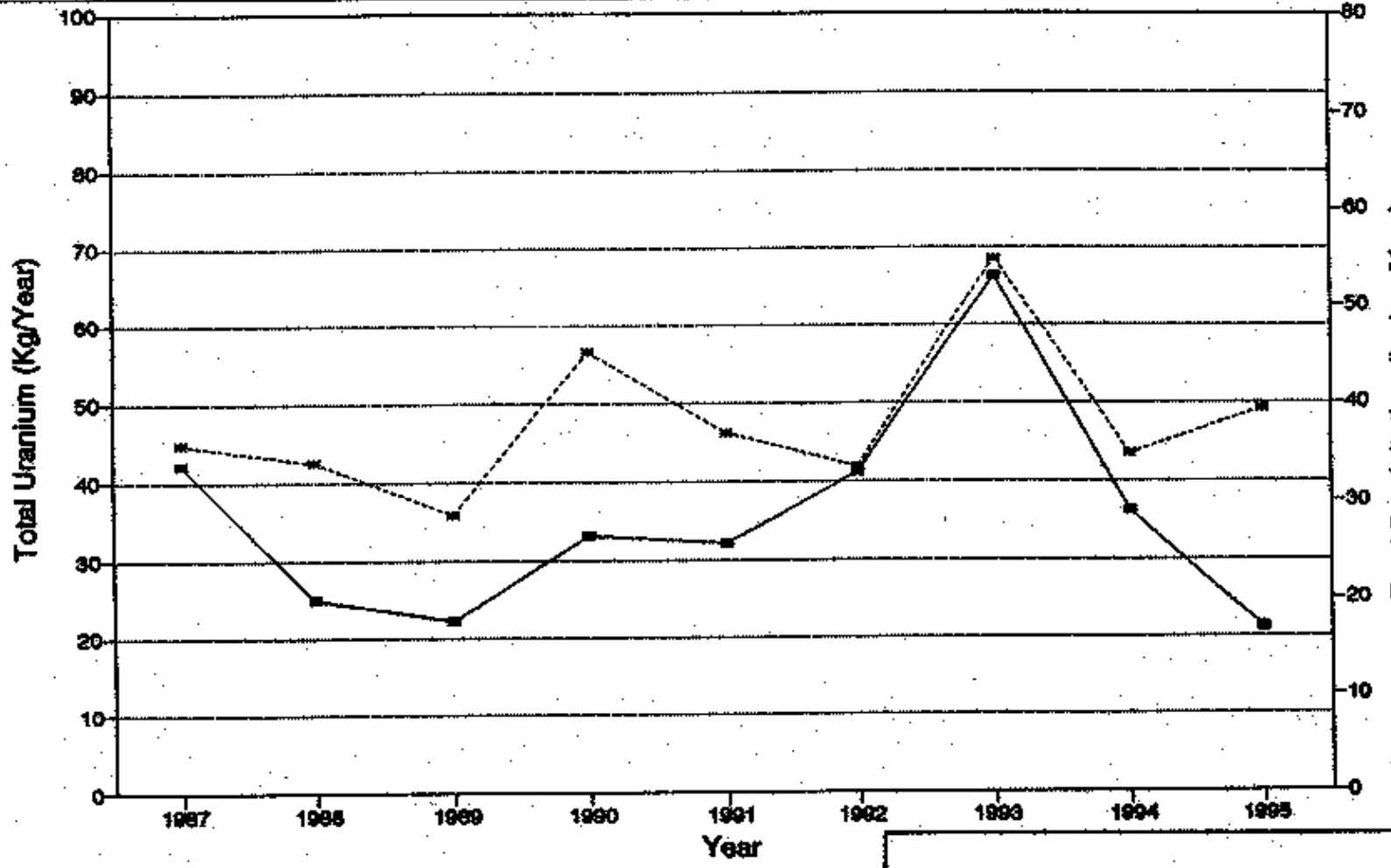
11.1.1 Off-Site Migration of Uranium in Storm Water

In an effort to determine whether site activities have caused an increase in the off-site migration of uranium in storm water at the three major NPDES outfalls (NP-0002, NP-0003 and NP-0005), the data for the years 1987 through 1994 were reviewed and corrected where required, for several factors. The corrections were for precipitation, watershed areas and runoff coefficients and are outlined in the *Weldon Spring Site Environmental Report for Calendar Year 1994* (Ref. 66).

These data have been updated by the inclusion of 1995 data. The 1995 data do not require correction. The annual precipitation and total annual mass of uranium for the years 1987 through 1995 are plotted in Figure 11-1, Figure 11-2 and Figure 11-3. The mass, precipitation, and mass per inch of precipitation is shown in Table 11-1.

Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of Frog Pond and receives runoff from the eastern section of the chemical plant where most of the building dismantlement took place. Figure 11-1 indicates that the uranium migrating off site initially decreased, then increased with the beginning of building dismantlement in 1992. Uranium migration decreased in 1994 when

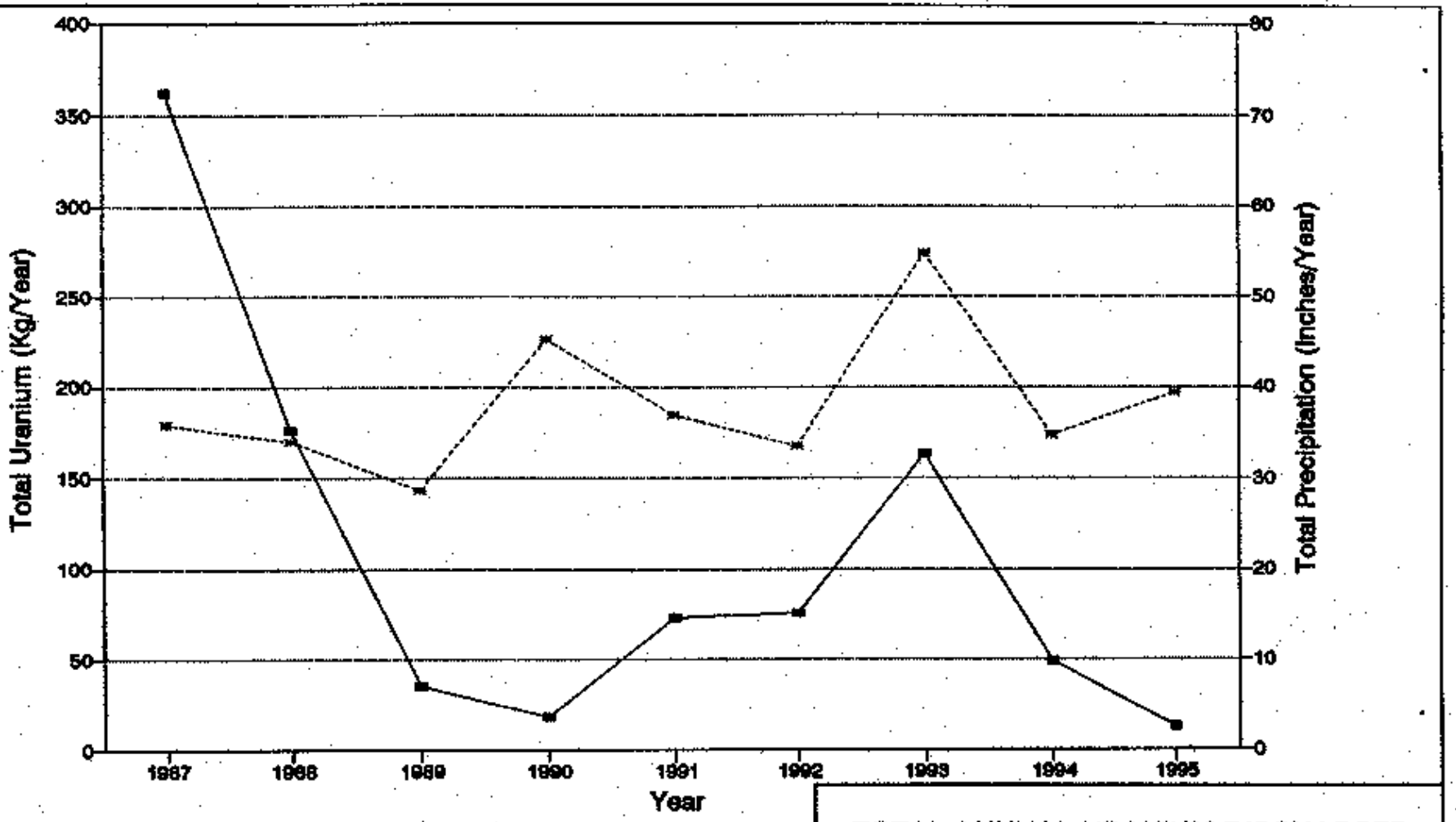


Annual Precip. — Corrected Mass

TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0002

FIGURE 11-1

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/PI/026/0395		
ORIGINATOR:	TDW	DRAWN BY:	GLN	DATE:	3/27/96

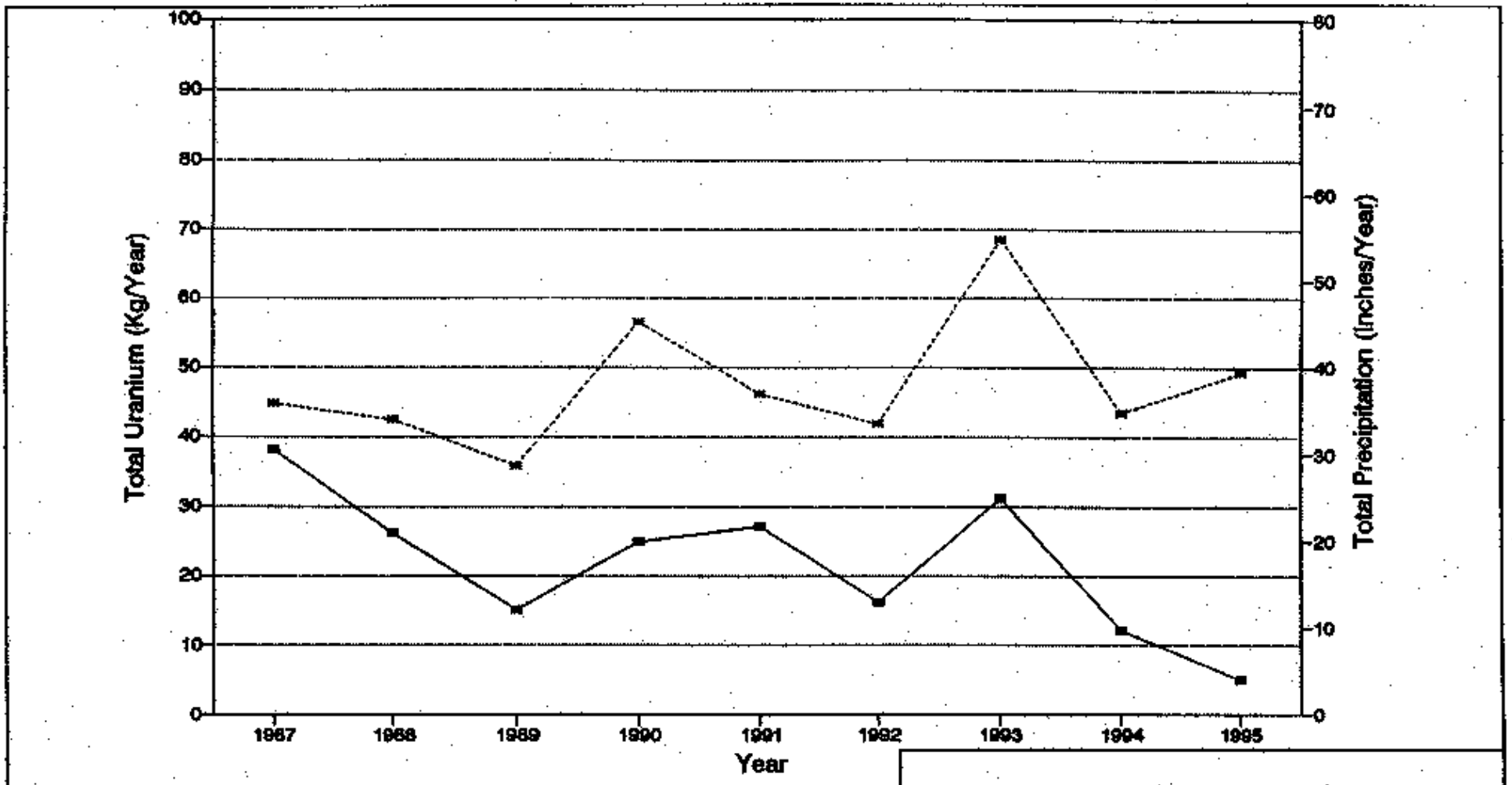


Annual Precip. Corrected Mass

TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0003

FIGURE 11-2

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/PI/027/0395
ORIGINATOR:	TDW	DRAWN BY:	GLN
DATE:	3/27/96		



TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0005

FIGURE 11-3

REPORT NO.:	DOE/OR/21548-592	EXHIBIT NO.:	A/PI/028/0395		
ORIGINATOR:	TDW	DRAWN BY:	GLN	DATE:	3/27/96

TABLE 11-1 Mass of Uranium Discharged from NPDES Storm Water Outfalls

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995
(PPT) (inches)	35.8	33.9	28.5	45.1	36.9	33.4	54.7	34.7	39.3
NP-0002 (kg)	42	25	22	33	32	41	66	36	20.6
Mass/inch of PPT (kg/in)	1.17	0.74	0.77	0.73	0.87	1.23	1.21	1.03	0.52
NP-0003 (kg)	362	176	35	17.7	73	75	163	49	12.6
Mass/inch of PPT (kg/in)	10.11	5.19	1.23	0.39	1.98	2.25	2.98	1.41	0.32
NP-0005 (kg)	38	26	15	25	27	16	31	12	5.0
Mass/inch of PPT (kg/in)	1.06	0.77	0.53	0.55	0.73	0.48	0.57	0.34	0.13

PPT Precipitation

corrective measures were taken and building dismantlement was finally completed. The figure also indicates that the uranium mass is proportional to the precipitation. The mass migrating off site per inch of precipitation was calculated and can be seen to initially decrease and then somewhat increase with the beginning of building dismantlement in 1992 (Table 11-1). With the completion of building dismantlement in 1994, the mass per inch of precipitation decreased slightly. Mass per inch of precipitation decreased sharply during 1995. Because the reduction was similar at all three outfalls, this is believed to be the result of relatively few heavy precipitation events with many widely scattered minor events. It also appears, from the data of individual storm events, that uranium concentration in storm water is as dependent on volume of storm water, length of precipitation event, and time between precipitation events as it is on activities that have taken place on site. For instance, heavy runoff often has lower uranium concentrations and lighter runoff, or the tail end of heavier runoffs, will often have relatively higher uranium concentrations.

Storm Water Outfall NP-0003

Figure 11-2 indicates that uranium migrating off site sharply decreased between 1987 and 1989 at Outfall NP-0003. This was a result of the construction of the Ash Pond diversion channel, which was started during November of 1988 and completed in April of 1989. The diversion channel diverted much of Outfall NP-0003 flow around the highly contaminated Ash Pond area preventing it from flowing through the pond as it had in the past. The only flow from

Ash Pond currently is storm water runoff from precipitation falling directly within the pond. The annual uranium mass at Outfall NP-0003 is highly dependant on the flow from Ash Pond. During the summer, and other dry periods, there may be little or no flow from the pond. As a result, the diversion channel flow from much less contaminated areas of the site, makes up the bulk of the flow. This causes lower uranium concentrations at the outfall. During winter, when the Ash Pond soils have become saturated and precipitation may be higher, flows from Ash Pond increase and concentrations at the outfall have trended higher. There has been little soil disturbance or other activity within the NP-0003 watershed through 1995.

The mass during 1990 for NP-0003 was exceptionally low. Although precipitation was fairly high, the randomly collected samples may have been collected when Ash Pond was not discharging. In 1991 and 1992 mass per inch of precipitation was similar at 1.98 and 2.25. In 1993, when precipitation was very high and massive flooding of the Missouri and Mississippi Rivers occurred, it can be observed that the mass per inch of precipitation increased slightly to 2.98, but still remained in the range of previous years. The mass per inch of precipitation decreased during 1994 to 1.41 because: precipitation was much less than in 1993; Ash Pond discharged very little; and a soil cover was placed over the South Dump area of the pond and the pond itself during the middle of the year, which decreased the concentration of uranium in the Ash Pond water. The covers were placed because Ash Pond is being used as a storage area; therefore, Ash Pond became a managed area and the DOE requires that the waters flowing from a managed area have uranium concentrations less than 600 pCi/l (19.2 Bq/l). If the concentration is higher than 600 pCi/l (19.2 Bq/l), the water is retained and treated therefore it would not contribute to outfall NP-0003.

Mass per inch of precipitation decreased sharply during 1995 to 0.32. Because the reductions were similar at all three outfalls, this is believed to be the result of numerous widely scattered minor precipitation events with relatively few heavy precipitation events.

In summary, precipitation has had the greatest effect on the mass of uranium migrating off site at NP-0003, and the Ash Pond diversion channel and the capping of areas of the pond have helped reduce uranium migration.

Storm Water Outfall NP-0005

Measurements at outfall NP-0005, the Southeast Drainage outfall, indicate that the annual mass of uranium migrating off site has been proportional with precipitation (Figure 11-3). The construction of the site water treatment plant beginning in 1992, with much earth disturbance for construction of the effluent and equalization basins, appears to have had little, if any, effect on the outfall. A siltation basin was constructed to settle sediments from the water flowing off the treatment plant area. The storm water from the treatment plant site sedimentation basin is generally less than 10 pCi/l (0.37 Bq/l) for uranium. The other major source for the outfall is a watershed that drains the highly contaminated Building 301 area. This area has been partially capped in an effort to decrease the concentration of uranium in storm water leaving the area. The concentration of uranium in storm water from the individual sampling events is highly depeqdant on precipitation rates, periods between precipitation, and the ratio of flow from the sedimentation basin and the Building 301 area. Although concentrations from the 301 area have been high (sometimes greater than 1,000 pCi/l [37 Bq/l]), Table 11-2 indicates that the mass of uranium per inch of precipitation has remained fairly steady and even decreased somewhat. Mass per inch of precipitation decreased sharply during 1995. Because the reduction was similar at all three outfalls, this is believed to be the result of numerous widely scattered minor precipitation events with relatively few heavy precipitation events.

In conclusion, it appears that although site activities can cause increases in off-site migration of uranium, the major factors causing event-to-event variations are total precipitation and precipitation rates. Mitigation measures have been effective in reducing the migration of uranium off site and in maintaining the migration at steady levels.

11.1.2 Raffinate Pit Sludge Biodenitrification

Bench scale testing is underway to determine if it is possible to biodenitrify the raffinate pit sludge. The systems are designed to simulate in situ treatment. The initial nitrate levels in the sludge were 3,500 mg/l NO3-N. As of March 4, 1996 the nitrate levels have dropped to 1,000 mg/l NO3-N after a period of 45 days. A summary report with recommendations is expected in 1996.

11.1.3 Baseline Monitoring at NPDES Outfalls NP-0002, NP-0003, and NP-0005

The NPDES storm water outfalls NP-0002, NP-0003, and NP-0005 were sampled for Ra-226, Ra-228, Th-228, Th-230, Th-232, 2,4-DNT, 2,4,6-TNT, hazardous substance list (HSL) metals, polychlorinated biphenyls (PCBs), and polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) starting in September 1994 and continuing through February 1995. These parameters were analyzed to establish pre-foundation removal baseline concentrations. The averages for the 6 months of baseline monitoring are shown in Tables 11-2 and 11-3. Radium and thorium were detected either at very low activities or were not detected. The chemical parameters were also present at low levels. The baseline concentrations will be used for comparison to results from future sampling.

TABLE 11-2 Average Radiological Concentrations (pCi/l) for Storm Water Outfalls NP-0002, NP-0003, NP-0005 Baseline Monitoring for September 1994 to February 1995

LOCATION	Ra-226	Ra-228	Th-228	Th-230	Th-232
NP-0002	0.45	0.88	0.53	0.34	0.35
NP-0003	0.40	0.63	0.37	0.39	0.35
NP-0005	0.48	0.94	0.31	0.29	0.26

Note: 1 pCi/l = 0.037 Bq/l

TABLE 11-3 Average Chemical Concentrations (μg/l) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995

LOCATION PARAMETER	NP-0002	NP-0003	NP-0005
2,4-DNT	<0.20[a]	<0.20[a]	<0.20[a]
2,4,6-TNT	<0.26[a]	<0.26[b]	<0.26[a]
Al	1.840*	1.302*	3.892*
Sb	11.67[a]	11.67[a]	11.67[a]
As	3.07	3.75	2.37

TABLE 11-3 Average Chemical Concentrations (μg/l) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995 (Continued)

LOCATION PARAMETER	NP-0002	NP-0003	NP-0005
Ba	80.97	82.13	90.85
Be	0.48	0.37	0.37
Cd	1.42	1.42	1.42
Ca	61,100*	78,433*	67,600*
Cr	5.16	5.01	6.77
Co	3.40	3.40	3.93
Cu	7.20	5.92	7.03
Fe	1,603*	1,152*	2,888*
Pb	7.65	3.33	4.33
Li	14.23	4.95	4.33
Mg	12,215*	14,467*	12,352*
Mn	185.85	41.28	73.67
Hg	0.24	0.08	0.08
Mo	6.13	7.15	5.70
Ni	10.23	10.83	12.40
K	5,21*	5,03*	3,71*
Se	2.38	3.23	1.94
Ag	1.93	1.93	1.67
Tl	2.81	1.98	1.85
V	4.47	4.68	8.45
Zn	55.40	31.28	48.75
PCBs	[c]	1.0[d]	1.0[d]
PAHs	<20[e]	<20[e]	<20[e]

TABLE 11-3 Average Chemical Concentrations (μg/l) for Storm Water Outfalls NP-0002, NP-0003, and NP-0005 Baseline Monitoring for September 1994 to February 1995 (Continued)

* mg/l
(a) All nondetect
(b) All nondetect with one detect of 0.0491 μg/l.
(c) N.D. at <1.0 except 1 detect at 0.18μg/l and one Aroclor-1221 N.D. at D.L. of 2.0 μg/l.
(d) Except one Aroclor-1221 N.D. at D.L. of 2.0 μg/l.
(e) All N.D. with the maximum D.L. being 20 μg/l.

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DOE ORDERS

5000.3B, *Occurrence Reporting and Processing of Information*
5400.1, *General Environmental Protection Program*
5400.3, *Hazardous and Mixed Waste Program*
5400.5, *Radiation Protection of the Public and the Environment*
5480.1B, *Environment, Safety and Health Program for Department of Energy Operations*

5480.4, *Environmental Protection, Safety, and Health Protection Standards*
5482.1B, *Safety Analysis and Review System*
5700.6C, *Quality Assurance*
5820.2A, *Radioactive Waste Management*

REGULATIONS

10 CFR 830.120, *Quality Assurance*
10 CFR 1022, *Department of Energy, Compliance With Floodplain/Wetlands Environmental Review Requirements*
36 CFR Part 800.5, *Protection of Historic and Cultural Properties*
40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*
40 CFR Part 141, *National Primary Drinking Water Regulations*
40 CFR 264, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*
40 CFR 761, *Polychlorinated Biphenyls, Manufacturing, Processing, Distribution in Commerce, and Use in Prohibitions*
40 CFR 761.125, *Requirements for PCB Spill Cleanup*
10 CSR 20-7.031, *Water Quality Standards*
10 CSR 25-7, *Hazardous Waste Management Commission - Rules Applicable to Owners/Operators of Hazardous Waste Facilities*

PROCEDURES

ES&H 3.1.7, *Noise Monitoring*
ES&H 4.1.4, *Quality Control Samples for Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection Procedures*
ES&H 4.2.1, *Erosion Control Survey*
ES&H 4.2.3, *Embankment Survey*
ES&H 4.9.3, *Data Review Procedures for Surface Water, Groundwater, and Soils*
MGT-6, *Surveillances and Walkthroughs*

13 GLOSSARY, ACRONYMS, AND ABBREVIATIONS

13.1 Technical Terms

ABSORBED DOSE: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray).

ACTIVITY: The rate at which the atoms of a radioactive material decay (transform). Activity is expressed in units of curie (or becquerel).

ALARA: An acronym for "As Low as Reasonably Achievable." This refers to the U.S. Department of Energy goal of keeping releases of radioactive substances to the environment and exposures of humans to radiation as far below regulatory limits as "reasonably achievable."

ALLUVIAL AQUIFER: A subsurface zone, formed by the deposition of sediments by running water, capable of yielding usable quantities of groundwater to wells.

ALPHA PARTICLE: A positively charged particle emitted from the nucleus during the radioactive decay of certain radionuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.

BACKGROUND RADIATION: Radiation due to cosmic rays and radiation from the naturally radioactive elements in the surface of earth.

BEDROCK: A rock formation usually underlying one or more unconsolidated formations.

BECQUEREL: The SI unit for activity. 1 becquerel (Bq) = 1 disintegration/second = 2.703×10^{-11} curies.

BETA PARTICLE: A charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

CHAIN-OF-CUSTODY FORM: A standardized form used in tracing the possession and handling of individual samples from the time of field collection through laboratory analysis.

COLLECTIVE POPULATION DOSE EQUIVALENT: The average total effective dose equivalent (TEDE) received by members of the public from exposure to radioactive material released by a DOE facility or operation, multiplied by the number of individuals in the population. Collective population dose equivalent is expressed in units of person-rem (or person-Sv).

COMMITTED DOSE EQUIVALENT: The predicted total dose equivalent to a tissue or organ over a 50-year period following a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert).

COMMITTED EFFECTIVE DOSE EQUIVALENT: The sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

CONTAMINATION: A foreign substance in or on the surfaces of soils, structures, areas, objects, or personnel.

COUNTING STATISTICS: Statistical analysis required to process the results of nuclear counting experiments and to make predictions about the expected precision of quantities derived from these measurements.

CURIE: A measure of the rate of radioactive decay. One curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dps), which is equal to the decay rate of one gram of Ra-226.

DECAY PRODUCTS: Isotopes that are formed by the radioactive decay of some other isotope. In the case of Ra-226, for example, there are 10 successive decay products, ending in the stable isotope Pb-206.

DERIVED CONCENTRATION GUIDE: The concentration of a radionuclide in air or water that, when an individual is continuously exposed by one exposure mode (ingestion of water, submersion in air, or inhalation), results in an effective dose equivalent of 100 mrem (1 mSv).

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well or spring) at a given instant in terms of volume per unit of time.

DOSE EQUIVALENT: The product of the average absorbed dose in a tissue or organ, measured in rad (or gray), and a radiation weighting factor (formerly known as quality factor). Radiation weighting factors ranging from 1-20 are assigned to all types of radiation (e.g., alpha, beta, gamma) depending on their ability to damage tissue. Dose equivalent is expressed in units of rem (or sievert).

DOSIMETER: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

EFFECTIVE DOSE EQUIVALENT: The summation of the products of the dose equivalents received by specified tissues of the body and tissue-specific weighting factors. It is used to estimate the risk of health effects of the exposed individual to ionizing radiation. Tissue specific weighting factors represent the fraction of the total health risk resulting from uniform whole-body irradiation contributed by a particular tissue. The effective dose equivalent includes contributions from internal deposition of radionuclides (committed effective dose equivalent) and the effective dose equivalent due to external exposure (gamma and/or X-rays). Effective dose equivalent is expressed in units of rem (or sievert).

ERG: Unit of Energy 1 ERG = 2.8×10^{-14} KWH

EXPOSURE PATHWAY: The route by which a contaminant or health hazard may enter and impact the environment or an individual.

EXTERNAL EXPOSURE: The fraction of dose equivalent contributed by penetrating radiation from sources external to the body (e.g., gamma and/or X-rays). Measured in rem (or sievert).

GAMMA RADIATION: Penetrating high energy, short wave-length, electromagnetic radiation (similar to X-rays) emitted during radioactive decay. Gamma rays are very penetrating and can be attenuated only by dense materials such as lead.

GROSS ALPHA: Measurement of all alpha-emitting radionuclides in a sample.

GROSS BETA: Measurement of all beta-emitting radionuclides in a sample.

HALF-LIFE: The time it takes for half the atoms of a quantity of a particular radioactive element to decay to progeny. Half-lives of different isotopes vary from small fractions of a second to billions of years.

HECTARE: A unit of area in the metric system equal to 10,000 square meters. It is approximately 2.5 acres.

HYDROLOGIC: Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

ISOTOPE: Nuclides having the same atomic number but different numbers of neutrons (mass numbers).

LLD: Lower limit of detection.

MDA: Minimum detectable activity.

NATURAL URANIUM: A naturally occurring radioactive element that consists of 99.2830% U-238, 0.7110% U-235, and 0.0054% U-234 by mass. On an activity basis, it consists of 48.6% U-238, 2.3% U-235, and 49.1% U-234.

NUCLIDE: A general term referring to isotopes of the chemical elements, both stable and unstable.

PERCHED LENSE: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

PROGENY: An element that results immediately from the disintegration of a radioactive element.

RAD: A unit of absorbed dose; acronym for radiation absorbed dose.

RADIATION: A very general term that covers many forms of particles and energy, from sunlight and radiowaves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, X-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIONUCLIDE: An unstable nuclide that undergoes radioactive decay.

RAFFINATE: A waste product from a refining process, i.e., that portion of a treated liquid mixture that is not dissolved and not removed by a selective solvent.

REM (Roentgen Equivalent Man): A quantity used in radiation protection to express dose equivalent for all forms of ionizing radiation. A rem is the product of the absorbed dose in rads and factors related to relative biological effectiveness.

SI: International System of Units.

SIEVERT: The SI unit used to quantify dose equivalent for all forms of ionizing radiation; 1 Sv = 100 rem.

STOCHASTIC: "Stochastic" effects are those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose, without a threshold.

WORKING LEVEL: Any combination of Rn-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of Rn-222 (or 8 pCi of Rn-220) in 1 liter of air, where the decay products are in radioactive equilibrium with the parent.

WORKING LEVEL MONTH: The product of WL and duration of exposure, normalized to a 1-month occupational exposure period (170 hours).

X-RAY: Penetrating electromagnetic radiation having a wave length that is much shorter than that of visible light. It is customary to refer to rays originating in the nucleus of an atom as gamma rays and to those originating in the electron field of the atom as X-rays.

13.2 Acronyms and Abbreviations

No abbreviations for common units of measure or chemical elements and compounds are included in this list. Some less common units of measure, such *pCi* and *μCi* are included.

ACM	asbestos-containing materials
AEC	Atomic Energy Commission
AHERA	Asbestos Hazard and Emergency Response Act
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARAR	applicable and/or relevant and appropriate requirements
ASME	American Society of Mechanical Engineers
BA	Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site
BOD	Biochemical Oxygen Demand
Bq	becquerel
CAA	Clean Air Act
CEDE	Committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curie
CLP	Contract Laboratory Program
CM&O	Construction Management and Operations
COD	chemical oxygen demand
CONOPS	Conduct of Operations
CWA	Clean Water Act
CX	categorical exclusion
DCG	Derived Concentration Guideline

DL/2	detection limit
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	data quality objective
EA	Environmental Assessment
EDAP	Environmental Data Administration Plan
EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Plan
EPA	Environmental Protection Agency
EPA	U.S. Environmental Protection Agency
EPPIP	Environmental Protection Program Implementation Plan
EQA	Environmental Quality Assurance
EQAPjP	Environmental Quality Assurance Project Plan
ES&H	Environmental Safety and Health
FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FHHS	Francis Howell High School
FP	Fire Protection
FS	Feasibility Study for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site
HAP	hazardous air pollutants
HMWM	Hazardous Materials Waste Management
HP	Health Physics
HPO	Missouri Department of Natural Resources Historical Preservation Officer
HQ	Headquarters
HSL	Hazardous Substance List
HVAC	heating, ventilating, and air conditioning
IH	Industrial Hygiene
IS	Industrial Safety
LDR	Land Disposal Restrictions
LLD	lower limit of detection

MACT	Maximum Available Control Technology
MCL	maximum contaminant level (Safe Drinking Water Act)
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDNR	Missouri Department of Natural Resources
MDOC	Missouri Department of Conservation
MHTC	Missouri Highway Transportation Commission
MSA	material staging area
msl	mean sea level
NAAQS	national ambient air quality standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
PCB	polychlorinated biphenyl
pCi	picocurie
PCM	phase contrast microscopy
PMC	Project Management Contractor
PP	Proposed Plan for Remedial Action and the Chemical Plant Area of the Weldon Spring Site
ppm	parts per million
PTI	Project Training and Improvement
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QA	Quality Assurance
QAMS	Quality Assurance Management Staff
QAPjP	Quality Assurance Project Plan
QWTP	quarry water treatment plant
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study

ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Saturation Indexes
SIC	Standard Industrial Classification
SOP	Standard Operating Procedures
SWATS	Site Wide Audit Tracking System
SWTP	site water treatment plant
TBP	tributyl phosphate
TC	toxicity characteristic
TDS	total dissolved solids
TEM	transmission electron microscopy
TLD	thermoluminescent dosimeter
TAB	trinitrobenzene
TND	dinitrotoluene
TNT	trinitrotoluene
tpy	tons per year
TSA	temporary storage area
TSCA	Toxic Substance Control Act
TSS	total suspended solid
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
WITS	Waste Inventory Tracking System
WLM	Working Level Monitor
WPC	Water Pollution Control
WSCP	Weldon Spring Chemical Plant
WSQ	Weldon Spring Quarry
WSRP	Weldon Spring raffinate pits
WSSRAP	Weldon Spring Site Remedial Action Project
WSUFMP	Weldon Spring Uranium Feed Materials Plant
l	liter
mg	milligram
mg/l	milligrams per liter

μCi	microcurie
μg/l	micrograms per liter
mSv	millisievert

APPENDIX A
Unpublished Documents

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

INTER-OFFICE CORRESPONDENCE

DATE: March 6, 1996

TO: Eric Danielson, PMC

FROM: Elizabeth Algutifan, PMC EKA

SUBJECT: **TELECON WITH KARL DAUBEL - WELDON SPRING TRAINING AREA CARETAKER**

TELECON

DATE AND TIME: 3/4/96 10:15 a.m.

PERSON RECEIVING CALL: Karl Daubel

CALLER: Elizabeth Algutifan

CONVERSATION WITH: Karl Daubel - Weldon Spring Training Area

PHONE NUMBER: (314) 441-8681

SUBJECT: Number of trainees at Weldon Spring Training Area each year

SUMMARY OF CONVERSATION:

Mr. Daubel stated that military trainees do not enter the portion of the training area adjacent to the WSCP fenceline; however, he and a few other employees do traverse this area occasionally.

ACTION OF FOLLOW-UP/RECOMMENDATIONS:

Use this information for Appendix B dose calculations - Dose from WSCP to MEI and collective populate dose sections.

SIGNED: Elizabeth Algutifan

MK-FERGUSON
A HONEYWELL-KAISER COMPANY

REPORT OF TELECON

TO: Julie Reitinger

FROM: Linda Meyer , Community Relations

DATE: 01/04/96

TIME: 9:00 A.M

INCOMING _____

OUTGOING XX

Phone Message from:
Claudia Geile, Assistant to the Principal

Phone: _____

Of: Francis Howell H.S.

And: _____

Phone: _____

Of: _____

Subject: Updated Staff/Student Numbers for Francis Howell H.S.

SUMMARY OF CONVERSATION:

Linda Meyer contacted Francis Howell H.S. and talked to Claudia to request updated student enrollment and staff totals for the 1995-1996 school year. Claudia stated that the total number of students attending FHHS is 2,427. Staff including administration, support and teaching staff total is 200. The Francis Howl District Administration Annex has 35 people that report for work at the annex and this staff comes and goes routinely.

ACTION OR FOLLOW-UP/RECOMMENDATIONS:

None

Linda L Meyer
Signature

Distribution: M. Picel
J. Meier
J. Pier
RC-25-01-08-01

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Eric Danielson
From: Lisa Dunham

Incoming: ___ Outgoing: X WP#: ____
Date: 1-17-96 Time: 11:32 a.m.

Conversation With:

Jerry Jones Phone: (314) 441-8471
of: Mo. State Highway Department-Weldon Spring
and: ____ Phone: ____
of: ____

Subject: Total number of employees at the Weldon Spring Maintenance site

Summary of Conversation:

Jerry Jones informed me that there are currently nine (9) employees working at the Missouri Highway and Transportation Department's Weldon Spring Maintenance site.

Jerry also stated that all correspondence for the Weldon Spring Maintenance site should be routed to the district office in Chesterfield at the following address:

Missouri State Highway & Transportation Dept.
Weldon Spring Maintenance Department (Hwy 94)
1590 Woodlake Dr.
Chesterfield, Missouri 63017

Action of Follow-Up/Recommendations:

cc: Ken Warbritton

By: Lisa Dunham

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

REPORT OF TELECON

TO: Julie Reitinger

INCOMING XX

FROM: Lisa Dunham, Comm. Relations

OUTGOING _____

DATE: 01/09/96

TIME: 7:00 A.M

Summary of Conservation with:
Jim Garr

Phone: (314) 441-4554

Of: Busch Conservation Area, Missouri Department of Conservation (MDC)

And: _____

Phone: _____

Of: _____

Subject: Updated Staffing Numbers and Annual Visitor Totals

SUMMARY OF CONVERSATION:

Jim Garr returned Lisa Dunham's phone call in regard to a request to provide updated staffing numbers for the Busch Conservation Complex. Jim left a voice message for Lisa stating that there are 16 full-time employees, and 10 to 20 part-time staff that are employed during seasonal periods. The total number of visitors at the Complex is estimated at 500,000 visitors per year.

ACTION OR FOLLOW-UP/RECOMMENDATIONS:

None.

Lisa Dunham
Signature

Distribution: L. Meyer
J. Meier
J. Pier
M. Picel
RC-25-01-08-01

FC-

APPENDIX B
Assumptions and Scenarios for Dose Calculations

A. Dose from the chemical plant/raffinate pits to a maximally exposed individual.

In previous years, a dose equivalent for the ingestion pathway was calculated for a maximally exposed individual (MEI) who frequents Busch Conservation Area and ingests fish, sediment, and water from the Busch lakes while swimming and fishing. The ingestion dose was then used in estimating a total effective dose equivalent to the MEI. Changing conditions at the Weldon Spring Chemical Plant (WSCP) area during 1995, including accumulation of quarry bulk waste at the temporary storage area (TSA) and completion of building dismantlement activities, made this scenario no longer applicable. Annual radioactive air particulate, radon, and gamma exposure rate measurements at Busch Conservation Area and along the north perimeter of the WSCP were not statistically greater than background levels; however, background levels were exceeded along the southwest perimeter of the WSCP in the vicinity of the TSA for these exposure pathways. A new scenario was thus developed to consider an MEI who frequents the Weldon Spring Training Area in the vicinity of the site perimeter 10 hours per year. Calculations using the new scenario result in a more conservative dose equivalent estimate to an MEI than if the previous scenario was used.

1. Inhalation :

a. Airborne Radioactive Particulates: Statistical analysis of gross alpha results indicated that one monitoring station at the Weldon Spring Chemical Plant, AP-3004, was different than background levels. Station AP-3004 was used to evaluate the dose from the chemical plant and raffinate pits perimeter to a hypothetical maximally exposed individual at the Weldon Spring Training Area. The net annual concentration at the station was 1.7E-16 μCi/ml or 1.7E-4 pCi/m^3 and was assumed to be Th-230. An exposure time of 10 hours per year and a breathing rate of 1.25 m^3/hr were assumed for the dose estimate.

CEDE (inhalation of airborne radioactive particulates)	=	net airborne particulate concentration x exposure time x breathing rate x dose conversion factor (DCF)
	=	1.7E-4 pCi/m^3 x 10 hr x 1.25 m^3/hr x 2.60E-1 mrem/pCi
	=	5.5E-4 mrem (5.5E-6 mSv)

(1) Uranium dose conversion factor (DCF) was the greater of the two DCFs reported for each uranium isotope (U-234 and U-238) in Table 2.2 of Eckerman it al. (Ref. 28).

b. Radon and Thoron Gas: Statistical analysis of integrated radon (Rn-220 and Rn-222) alpha track monitoring results indicated that one station at the WSCP perimeter, RD-3003, exceeded the annual average background concentration. Because there was no reason to suspect that the annual average Rn-220 concentration at station RD-3003 was greater than background, the integrated radon concentration was assumed to be Rn-222 only. Based on previous measurements (Ref. 53), a daughter equilibrium ratio of 0.10 was used.

Radon concentrations are often expressed in units of working levels (WL), where 1 WL (at 100% equilibrium) is equal to 100 pCi/l for Rn-222. Radon exposure is often expressed in terms of working level months (WLm), corresponding to an exposure of 1 WL during the reference working period of 170 hours (one working month).

CEDE (inhalation of Rn-222 gas)	=	net integrated radon concentration x exposure time x daughter equilibrium ratio x working month conversion factor
	=	0.3 pCi/l x 10 hrs x 0.10 x 1 WL/100 pCi/l x 1.25 rem/WLm x 1 working month/170 hrs x 1000 mrem/rem
CEDE (Rn-222)	=	0.022 mrem (0.00022 mSv)
CEDE (inhalation)	=	CEDE (air particulates) + CEDE (Rn-222)
	=	0.023 mrem (0.00023 mSv)

2. External Gamma Pathway: Statistical analysis of environmental TLD results indicated that one station at the WSCP, TD-3003, was greater than background. This station measured a gross annual gamma exposure of 78 mrem (0.78 mSv). Given an average background gamma radiation exposure of 62 mrem (0.62 mSv), a net annual gamma exposure of 16 mrem (0.16 mSv) was obtained for the monitoring location. The effective dose equivalent (EDE) due to gamma exposure for a MEI at the Weldon Spring Training Area is thus:

EDE (external) = (gross TLD result - background TLD result) x exposure time

= (78 - 62) mrem/y x 10 hr x 1 y/8,760 hr

= 0.018 mrem (0.00018 mSv)

3. Ingestion Pathway: Because no bodies of water exist at the Weldon Spring Training Area, fishing, swimming, and ingestion of contaminated water do not constitute realistic scenarios.

The total effective dose equivalent is calculated as follows:

TEDE = CEDE (inhalation) + EDE (external)

= 0.023 mrem + 0.018 mrem

= 0.041 mrem (0.00041 mSv)

B. Dose from the Weldon Spring Quarry to a Maximally Exposed Individual

The exposure scenario for the dose estimate from the Weldon Spring Quarry is based on a hypothetical individual who hikes around the southeastern perimeter of the quarry 5 hours per year.

1. Inhalation Pathway:

a. Airborne Radioactive Particulates: Results of gross alpha measurements at the quarry indicated three stations with results statistically greater than background averages for 1995. The highest annual average net concentration, 7.1E-4 pCi/m^3, was measured at station AP-1009, located on the northeast portion of the quarry perimeter. This concentration was used in evaluating dose to the maximally exposed individual, and was assumed to be Th-230. A breathing rate of 1.25 m^3/hr was assumed.

CEDE (air particulates) = Net Airborne Particulate Concentration x Exposure Time x Breathing Rate x Dose Conversion Factor

= 7.1E-4 pCi/m^3 x 5 hr x 1.25 m^3/hr x 0.26 mrem/pCi
= 0.0012 mrem (1.2E-5 mSv)

b. Thoron and Radon Gas: Concentrations of thoron and radon at the southeastern perimeter of the quarry were estimated using concentrations measured at station RD-1002, located along the eastern portion of the quarry perimeter. During excavation work at the quarry in 1995, elevated measurements were reported, especially during the first and second quarters. Thoron data was provided by modified "M-type" alpha-track detectors, and thoron concentrations were calculated using Pearson's method (Ref. 49).

While the annual average integrated radon concentration at RD-1002 was statistically greater than background, further analysis indicated that virtually all of this measurement was due to Rn-220. The annual average Rn-222 concentration around the quarry perimeter was indistinguishable from background levels. Thus, the radon contribution to the 1995 TEDE for a maximally exposed individual near the quarry was assumed to include Rn-220 only.

In 1995, the net annual average Rn-220 concentration at station RD-1002 was 0.7 pCi/l. A daughter equilibrium ratio of 10% was assumed (Ref. 53). The committed effective dose equivalent is calculated as follows:

CEDE (thoron) = net thoron concentration x exposure time x daughter equilibrium ratio x dose conversion factor x working month dose conversion factor

= 0.7 pCi/l x 5 hrs x 0.1 x 1 WL/8.0 pCi/l x 0.42 rem/WLM x 1 working month/170 hrs x 1000 mrem/rem

CEDE (thoron) = 0.108 mrem (0.00108 mSv)

CEDE(inhalation)= CEDE (air particulates) + CEDE (thoron)

= 0.109 mrem (0.00109 mSv)

2. External Pathway: Environmental TLD monitoring station TD-1003, located along the quarry perimeter, was found to be statistically greater than background levels. TD-1003 provided a total annual gross measurement of 77 mrem. An average background gamma radiation dose equivalent of 62 mrem was estimated for the year.

EDE (external) = (gross TLD result - background TLD result) x exposure time

= (77 - 62) mrem/y x 5 hrs x 1 y/8,760 hrs

EDE (external) = 0.0086 mrem (8.6E-5 mSv)

3. Ingestion pathway: Because the quarry is controlled by a 2.4 m (8 ft) high fence, fishing, swimming, and drinking water at the quarry do not constitute realistic scenarios.

TEDE = CEDE (inhalation) + EDE (external)

= 0.109 mrem + 0.0086 mrem

= 0.12 mrem (0.0012 mSv)

The total estimated effective dose equivalent to a maximally exposed individual at the quarry is therefore 0.12 mrem (0.0012 mSv).

C. Dose from the Vicinity Properties to a Maximally exposed Individual

1. Inhalation Pathway:

a. Airborne Radioactive Particulates:

The Femme Osage Slough, located adjacent to the Weldon Spring Quarry, is the only portion of the vicinity properties which would likely be frequented by members of the public. Statistical analysis of gross alpha results at Station AP-1010, which is the air particulate monitoring location closest to the slough, indicated an annual average concentration higher than background levels. The annual average net concentration at AP-1010 was 2.9E-16 μCi/ml, or 2.9E-4 pCi/m^3, and was assumed to be Th-230. It is assumed that the maximally exposed individual visited the slough for the purpose of fishing 25 times per year, 2.5 hours per visit. Therefore, the individual fishes at the slough 62.5 hours per year.

CEDE (inhalation, air particulates) = net airborne particulate concentration x exposure time x breathing rate x dose conversion factor (DCF[1])

= 2.9E-4 pCi/m^3 x 62.5 hr x 0.96 m^3/hr x 0.26 mrem/pCi

= 0.0045 mrem (4.5E-5 mSv)

b. Radon Gas: Not applicable since radon concentrations measured at the slough were indistinguishable from background levels.

CEDE (inhalation) = 0.0045 mrem (4.5E-5 mSv)

2. External Gamma Pathway: Not applicable since there is no reason to suspect at the 95% confidence level that external gamma radiation results at the slough are greater than background levels.

3. Ingestion Pathway: The Femme Osage Slough contains uranium contaminated sediments and was considered in estimating the committed effective dose equivalent to a hypothetical individual via the fish ingestion pathway. Due to the stagnant conditions at the slough, ingestion of water or sediments was deemed unrealistic.

Assume a 6.5 g/day fresh water fish consumption rate (Ref. 23) from the slough. Assume the average uranium concentration in fish collected from the slough of 0.005 pCi/g.

CEDE (ingestion) = fish consumption rate x uranium concentration x dose conversion factor (DCF[1])

= 6.5 g/day x 365 d/yr x 0.005 pCi/g x 2.83E-4 mrem/pCi

= 0.0034 mrem (0.000034 mSv)

TEDE = CEDE (inhalation) + CEDE (ingestion)

= 0.0045 mrem + 0.0034 mrem

= 0.0079 mrem (7.9E-5 mSv)

The total estimated effective dose equivalent for the maximally exposed individual at the Femme Osage Slough is therefore 0.0079 mrem (7.9E-5 mSv).

D. Collective Population Dose Estimate

Exposure points are locations where members of the public are potentially being exposed to above-background concentrations of (1) airborne radioactive particulates, (2) radon gas

concentrations, (3) external gamma radiation, or (4) radionuclides in food or water. All four pathways are addressed for the collective population dose estimate. Exposure to above-background radionuclide concentrations in food or water is applicable only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area. Three of the lakes on this property receive runoff from the site and are used by the general public for fishing and boating purposes. None of these bodies of water are used as drinking water sources.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the site or from materials stored at the site. If there is no reason to suspect that environmental monitoring results are different from the appropriate background monitoring results, then the area surrounding the environmental monitoring station cannot be considered an exposure point. Therefore, the population near the station, as well as the population beyond the station, is not included in the collective population dose estimate.

The only area where there was reason to suspect that environmental air monitoring results could be different than background concentrations was at the portion of the Weldon Spring Training Area near the WSCP perimeter. However, military personnel who train there do not frequent the area near the WSCP fenceline; reportedly only a few staff members walk in this area on an occasional basis (see Appendix A, Telecon). Furthermore, the critical receptor monitoring location at the Army property indicated no elevated levels of air particulates, radon gas, or gamma exposure. Thus, a collective population dose scenario for users of the Weldon Spring Training Area was deemed to be unrealistic.

Other potential populations to consider for estimating a collective population dose equivalent were users of the Katy Trail and visitors to the Busch Conservation Area. The Katy Trail scenario was deemed unrealistic due to background levels of radioactive air particulates, radon gas, and gamma exposure rate in the vicinity of these areas. The only area where there was reason to suspect that a significant amount of the general population could consume fish, water, and sediments from waters that receive runoff from the site was at the Busch Memorial Conservation Area. The only potential receptors in that area are the people who actually use the Busch Memorial Conservation

property for recreational purposes. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the Weldon Spring site and are used for fishing and boating activities. The Missouri Department of Conservation recently conducted a year long survey to determine the number of visitors to the area, the types of activities in which users participate, and the amount of time allocated for these activities.

Fishing at the Busch Conservation Area averaged 2.5 hours per visit for the approximately 160,000 visits to the area for that purpose (assuming a time-spent to fish-caught ratio of 0.4 fish/hour and a 0.50 ratio of fish caught to fish kept for a total of 80,000 fish). Assuming that one person keeps one fish, the population of concern would be 80,000 persons. For the water and sediment ingestion scenarios, boating is the activity assumed to provide the potential for incidental water and sediment ingestion. An estimated 5,985 visits were made for the purpose of boating with an average of 5.7 hours per visit. Assuming that each visit constitutes one individual, the total population would be 5,985 persons. Each of these ingestion scenarios is further addressed in calculations one, two, and three below.

Population Dose Estimate for Users of the Busch Memorial Conservation Area

1. Population dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area.

   a. Assuming that each person of the 80,000 population consumes one fish and that the edible portion of a fish has a mass of 200 g, the average consumption rate specific to the affected population is 0.55 g/person/day.

   b. Using the total uranium fish content of 0.009 pCi/g obtained from samples collected in Lake 36 and the population specific consumption rate derived from Missouri Department of Conservation data, the estimated population dose is:

Population Dose Estimate (fish ingestion)

= consumption rate x total uranium concentration in fish x exposure time x dose conversion factor x persons

= 0.55 g/day x 0.009 pCi/g x 365 day x 2.83E-4 mrem/pCi x 80,000 persons x 1 rem/1,000 mrem

= 0.041 person-rem (0.00041 person-Sv)

2. Population dose estimate due to incidental ingestion of water at the Busch Conservation lakes:

   a. Assume that each person of the 5,985 population makes one boating visit on an annual basis and 5% of the visit is spent swimming (0.285 hours/visit).

   b. Using the total uranium surface water content of 67.5 pCi/l obtained from Lake 36 and an ingestion rate of 0.05 l/hour (Ref. 23) the estimated population dose is

Population Dose Estimate (water ingestion)

= ingestion rate x total uranium concentration in surface water x exposure time x dose conversation factor[1] x persons

= 0.05 l/hr x 67.5 pCi/l x 0.285 hr x 2.83E-4 mrem/pCi x 5,985 persons x 1 rem/1,000 mrem

= 0.0016 person-rem (0.000016 person-Sv)

3. Population dose estimate due to ingestion of sediments at the Busch lakes:

   a. Assume that each person of the 5,985 population makes one boating visit on an annual basis and 5% of the visit is spent swimming (0.285 hours/visit).

b. Using the total uranium sediment content of 91.1 pCi/g obtained from Lake 34 and an ingestion rate of 200 mg/day, the estimated population dose is:

Population Dose Estimate (sediment ingestion)

= ingestion rate x total uranium concentration in sediment x exposure time x dose conversion factor[1] x persons

= 200 mg/day x 91.1 pCi/g x 0.285 hr/person x 2.83E-4 mrem/pCi x 5,985 persons x 1 g/1,000 mg x 1 day/24 hr x 1 rem/1,000 mrem

= 0.0004 person-rem (4E-6 person-Sv)

Population Dose Estimate (Busch) = Population Dose Estimate (ingestion)

= 0.043 person-rem

Population Dose Estimate (total) = Population Dose Estimate (Busch)

= 0.043 person-rem (0.00043 person-Sv)

The total collective population dose equivalent for 1995 is 0.043 person-rem (0.00043 person-Sv)

E. Airborne Radioactive Release Estimates

Weldon Spring Chemical Plant

During 1995, no high volume critical receptor monitors indicated radioactive air particulate concentrations statistically greater than background levels. However, low volume perimeter monitoring station AP-3004, located just to the west of the temporary storage area (TSA), indicated above background gross alpha results for the year. No other WSCP perimeter monitoring stations were statistically greater than background for the year. On an activity basis, the primary contaminant within the quarry bulk waste is Th-230. Other radiological components in the waste include U-234, U-235, U-238, Th-228, Th-232, Ra-226, and Ra-228. The above

background measurements probably resulted from storage of radiologically contaminated quarry bulk waste at the TSA.

The net annual average concentration measured at Station AP-3004 was 1.7E-16 μCi/ml. This result was incorporated into a box model to estimate the total radioactive airborne particulate release from the WSCP. The fraction of the long-lived total alpha activity contributed by each radiological component in the quarry bulk waste (see Table B-1) was then multiplied by the total release rate, resulting in the release rate of each radionuclide.

TABLE B-1 Contribution to Total Alpha Activity of Radionuclides Contained in Quarry Bulk Waste

RADIONUCLIDE	% CONTRIBUTION TO TOTAL α ACTIVITY/100
U-234	0.069
U-235	0.003
U-238	0.064
Th-228	0.022
Th-230	0.752
Th-232	0.036
Ra-226	0.052
Ra-228	0.040

The range of wind directions encompassing the sector in which the monitoring station is located was determined to be 214° - 281°, or the SW, WSW, and W sectors. The combined frequency at which the wind blew in these directions was found to be 13.8%, determined from an analysis of on-site 1995 meteorological data. The average wind speed for these sectors was 3.3 m/s.

A release height of 12.6 m was assumed for the model. The release height was estimated to be the approximate vertical distance from the monitoring station to the top of the TSA area source.

The box length was selected according to the approximate width (encompassing the SW, WSW, and SW wind sectors) of the source area perpendicular to a straight line measured from the monitoring station to the center of the source.

The radioactive airborne particulate release rate from the WSCP is estimated from the following equation:

Release Rate (Ci/y) = Box Length (m) x Release Height (m) x Wind Speed (m/s) x Net Annual AP-3004 Concentration (Ci/m^3) x 3.1536E7 seconds/year x Directional Frequency

Release Rate = 270 m x 12.6 m x 3.3 m/s x 1.7E-16 Ci/m^3 x 3.1536E7 seconds/year x 0.138

Total WSCP Release Rate = 8.3E-6 Ci/y

Weldon Spring Quarry

Annual measurements at three low volume radioactive air particulate monitoring stations at the quarry indicated concentrations statistically greater than background levels for 1995. These were AP-1009, AP-1010, and AP-1015. Net annual averages from these stations were incorporated into a series of three box models to estimate the total radioactive airborne particulate release from the quarry for the year. As for the WSCP, a range of wind directions encompassing the sector in which a given monitoring station is located was determined for each of the three stations. A release height of 6 m was assumed for all three box models, which is the estimated vertical distance from the quarry source area to the quarry rim, where the monitoring stations are located. Input data to the box models is provided in Table B-2.

TABLE B-2 Input Parameters for WSQ Box Models Used in Determining Total Uranium Release

MONITORING STATION	WIND SECTORS (WIND BLOWING TOWARD)	DIRECTIONAL FREQUENCY	AVERAGE WIND SPEED (m/s)	BOX LENGTH (m)	ANNUAL NET CONCENTRATION (Ci/m^3)
AP-1009	NE, ENE, E	0.091	2.3	120	7.1E-16
AP-1010	ESE, SE, SSE, S, SSW	0.408	2.6	220	2.9E-16
AP-1015	WNW, NW, NNW, N, NNE	0.320	3.5	270	3.4E-16

Quarry Airborne Particulate Release Calculations:

Release Rate (Ci/y) = Box Length (m) x Release Height (m) x Wind Speed (m/s) x Net Annual Gross Alpha Concentration (Ci/m^3) x 3.1536E7 seconds/year x Directional Frequency

Box 1 (AP-1009):
Release Rate = 120 m x 6 m x 2.3 m/s x 7.1E-16 Ci/m^3 x 3.1536E7 s/y x 0.091 = 3.4E-6 Ci/y

Box 2 (AP-1010):
Release Rate = 220 m x 6 m x 2.6 m/s x 2.9E-16 Ci/m^3 x 3.1536E7 s/y x 0.408 = 1.3E-5 Ci/y

Box 3 (AP-1015):
Release Rate = 270 m x 6 m x 3.5 m/s x 3.4E-16 Ci/m^3 x 3.1536E7 s/y x 0.320 = 1.9E-5 Ci/y

WSQ Release Rate = Box 1 Result + Box 2 Result + Box 3 Result
WSQ Release Rate = 3.5E-5 Ci/y

Multiplying the total release rate by the individual activity fractions listed in Table 3-1, the contribution of each listed radionuclide to the total release is:

U-234	3.0E-6 Ci/y
U-235	1.3E-7 Ci/y
U-238	2.8E-6 Ci/y
Th-228	9.5E-7 Ci/y
Th-230	3.2E-5 Ci/y
Th-232	1.5E-6 Ci/y
Ra-226	2.2E-6 Ci/y
Ra-228	1.7E-6 Ci/y

Total Airborne Particulate Release Rate (WSCP and WSQ) = 8.3E-6 Ci/y + 3.5E-5 Ci/y = 4.3E-5 Ci/y

F. Radon-220 and Radon-222 Release Estimates

Weldon Spring Chemical Plant

Annual measurements at Station RD-3003 indicated a net average Rn-222 concentration of 0.3 pCi/l above background. Annual average Rn-220 measurements along the WSCP fence line indicated no stations statistically above background levels. A box model similar to that used in determining the total uranium release rate from the WSCP was used to determine the Rn-222 release rate from the WSCP.

The range of wind directions encompassing the sector in which the monitoring station is located was determined to be 214° - 281°, or the SW, WSW, and W sectors. The combined frequency at which the wind blew in these directions was found to be 13.8%, determined from an analysis of on-site 1995 meteorological data. Average wind speed for the combined sectors was 3.3 m/s.

As explained in Section E of this appendix, a release height of 12.6 m was assumed for the model. The box length was estimated to be 270 m.

The Rn-222 release rate from the WSCP is estimated from the following equation:

Release Rate (Ci/y) = Box Length (m) x Release Height (m) x Wind Speed (m/s) x Net Annual RD-3003 Rn-222 Concentration (Ci/m^3) x 3.1536E7 seconds/year x Directional Frequency

Release Rate = 270 m x 12.6 m x 3.3 m/s x 0.3 pCi/l x 10^{-12} Ci/pCi x 1,000 l/m^3 x 3.1536E7 s/y x 0.138

WSCP Rn-222 Release Rate = 15 Ci/y

Weldon Spring Quarry

Annual measurements at station RD-1002 indicated a net average Rn-220 concentration of 0.7 pCi/l above background. Annual average Rn-222 measurements along the WSQ perimeter indicated no stations greater than background averages. A box model similar to that used for station AP-1009 in determining the total uranium release rate from the WSQ was used to determine the Rn-220 release rate from the WSQ.

The range of wind directions encompassing the sector in which the monitoring station is located was determined to be 34° - 101°, or the NE, ENE, and E sectors. The combined frequency at which the wind blew in these directions was found to be 9.1%, determined from an analysis of on-site 1995 meteorological data. Average wind speed for the combined sectors was 2.3 m/s.

As explained in Section E of this appendix, a release height of 6 m was assumed for the model. The box length was estimated to be 120 m.

The Rn-220 release rate from the WSQ is estimated from the following equation:

Release Rate (Ci/y) = Box Length (m) x Release Height (m) x Wind Speed (m/s) x Net Annual RD-1002 Rn-220 Concentration (Ci/m^3) x 3.1536E7 seconds/year x Directional Frequency

Release Rate = 120 m x 6 m x 2.3 m/s x 0.7 pCi/l x 10^{-12} Ci/pCi x 1,000 l/m^3 x 3.1536E7 s/y x 0.091

WSQ Rn-220 Release Rate = 3.3 Ci/y

Thus, the total Rn-222 and Rn-220 release rates for 1995 are:

Rn-222	15 Ci/y
Rn-220	3.3 Ci/y

APPENDIX C
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11 SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project that support and assist in the implementation of environmental protection policies. In addition, short term environmental studies are described that support regulatory requirements not specifically covered by U.S. Department of Energy (DOE) Order 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 42).

11.1 Special Studies

The special studies described in this subsection are short-term or one-time studies that support regulatory requirements not specifically covered by DOE 5400.1 or that were not planned in the *Environmental Monitoring Plan* (Ref. 42).

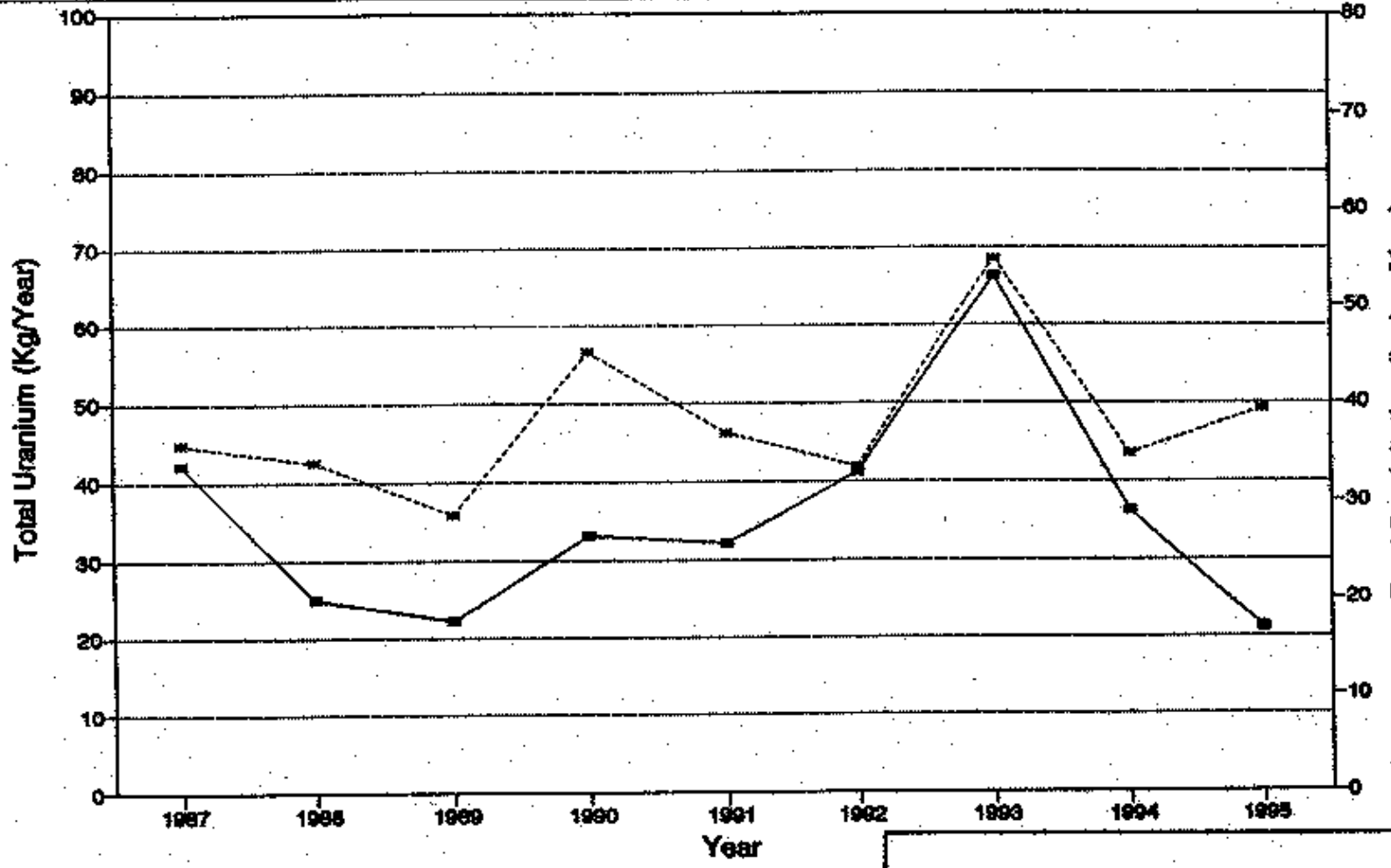
11.1.1 Off-Site Migration of Uranium in Storm Water

In an effort to determine whether site activities have caused an increase in the off-site migration of uranium in storm water at the three major NPDES outfalls (NP-0002, NP-0003 and NP-0005), the data for the years 1987 through 1994 were reviewed and corrected where required, for several factors. The corrections were for precipitation, watershed areas and runoff coefficients and are outlined in the *Weldon Spring Site Environmental Report for Calendar Year 1994* (Ref. 66).

These data have been updated by the inclusion of 1995 data. The 1995 data do not require correction. The annual precipitation and total annual mass of uranium for the years 1987 through 1995 are plotted in Figure 11-1, Figure 11-2 and Figure 11-3. The mass, precipitation, and mass per inch of precipitation is shown in Table 11-1.

Storm Water Outfall NP-0002

Outfall NP-0002 is downstream of Frog Pond and receives runoff from the eastern section of the chemical plant where most of the building dismantlement took place. Figure 11-1 indicates that the uranium migrating off site initially decreased, then increased with the beginning of building dismantlement in 1992. Uranium migration decreased in 1994 when



Annual Precip. — Corrected Mass

TOTAL ANNUAL URANIUM DISCHARGED
AT STORM WATER OUTFALL
NP-0002

FIGURE 11-1

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